ROADS AND STREETS

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Columbus Avenue in the Days of Touring Cars

WAY BACK WHEN—

Concrete Street Construction

FORTY YEARS AGO

Bellefontaine, Ohio, built the first concrete streets in the United States in 1892

THE concrete was mixed thoroughly dry, then the water was turned on and it was mixed just wet enough so that you could take a handful of this mixture and press it into a ball and throw like a snow ball, reports W. T. G. Snyder, the contractor who built the oldest concrete streets in the United States, regarding the water content of the concrete on this early work. These old concrete streets were built in 1892 and 1893 around the Logan County Court House, in the center of the business district of Bellefontaine, Ohio. The four streets, Columbus, Main, Court and Opera, contain about 7,700 square yards and today, forty years after this experiment was undertaken, has many years of service remaining. All the details of engineering and inspection was under the personal direction of the city engineer, J. C. Wonders, who was later district engineer for the U. S. Bureau of Public Roads at Omaha.

These old streets are of interest to engineers today because of the methods used in their construction and the excellent service they have given for four decades. It is of value to know that the principles of concrete proportioning and mixing recognized and used today as sound practice, were rigidly applied on these first concrete streets built ten years before the day of the automobile.

The construction of the paving came about by accident, in a way. The work was done by the engineer of Bellefontaine, who was called in by a lumber company to make a crossing driveway for a lumber com-

pany that would stand up under the heavy loads of lumber, coal, etc., and the hoofs of the heavy horses then used to haul wagons and drays.

Mr. Snyder put in the concrete driveway for the lumber company and it was so satisfactory that his work at once attracted the attention of city officials, later being called upon to put in the street work. By way of contrast with some work, it is to be noted that the driveway put in during the year 1892 for the lumber company, is still in use in its original form.

The two narrow streets, Opera and Court, on two adjoining sides of the courthouse square, were paved first, in 1892. The six in. pavement was placed in two courses, in strips 5½ ft. wide, by starting at one end of the block, working through to the other end and then going back and putting in succeeding strips until the street was paved full width. Each strip was marked off in blocks by inserting tarred paper transversely at about five foot intervals.

Before the concrete was placed, the street was excavated to a depth of 6 in., then carefully rolled and compacted. The base course of 4 in. was mixed by

Columbus Avenue at an age of 33 years. The pavement shows little wear except in the longitudinal joints. Its appearance today is very much the same

hand in the proportions of one part of cement to five parts of clean, unwashed gravel containing about one-third sand. This gave proportions af about 1:1.66:3.33. The aggregates and cement were first mixed dry, by hand, in boxes and then mixed in a continuous mixer with some water added. However, it was mixed quite dry so that when rammed with tampers 8 in. square, weighing 35 lb., moisture would just appear on the surface. In fact, it was mixed so dry that a moist surface was not always obtained. It was regular procedure for men with sprinkling cans to follow the ramming operation and wet down the dry spots which were then retamped. About 6 in. of loose concrete was required to give the 4 in. of compacted base.

The top course of 2 in. was then placed before the base course had started to harden and continuously rammed to bring mortar to the surface for finishing. The proportions of the top course were three parts of cement to five parts of sand, slightly richer than a one to two mortar. The specifications required all the sand to pass through screens having three openings to the inch and produced what is commonly known as torpedo sand. A minimum of water was likewise used in mixing the top course but it was necessary to have sufficient mortar on the surface to fill the low places when the surface was worked with a straight-edge or wooden float. Water was supplied to the dry places by a man

Court Street. The four old streets have given many years of service

with a sprinkling can so as to give the concrete sufficient moisture to finish nicely under a wooden float. The wooden float was followed with a steel trowel and this in turn followed with a small hand roller that made small indentations in the surface, in 2-in. patterns ¼ in. deep, to give horses a secure footing.

In speaking about the quality of concrete in general, Mr. Snyder states, "I have found that as a rule, contractors are as honest as any other class of business men and are just as proud of doing their work well, but they are not on the job at all times, being present only now and then and must trust to their foremen or their superintendents who are always kept busy looking after their men and materials and are unable to look after the mixing and the placing of the concrete and other materials on the roads, even if they so desired. Therefore, you can see the importance of inspectors."

The two wider streets on the opposite sides of the court house square, Columbus and Main, were paved

Opera Street. One of the two streets built in 1892

in October and November of the next year. The construction practices on these two streeets were essentially the same as on the two streets built in 1892. The proportions of aggregates were changed however and the base course was composed of one part of cement to four parts of gravel and the top course composed of equal parts of cement and torpedo sand. The same gravel, containing about one-third sand, was used and gave proportions of about 1:1.33:2.66.

Cold weather was experienced during almost the entire construction period of the 1893 work, with temperatures below freezing prevailing about every night. The dangers of frozen concrete were well appreciated even at this early date in concrete history. The construction procedure was, accordingly, changed to provide that each day's work be covered with sawdust to protect it from freezing at night.

The cost of this work in Bellefontaine compares very favorably with present day costs. It was contracted for at $2.15 a square yard and when it is considered that all material was loaded by hand and hauled by teams and all mixing, placing and finishings accomplished by hand methods, it can be seen that the streets were constructed at a very reasonable price.

In 1926, it was necessary to tear out a small part of one of the streets to make some underground public utility repairs. At that time the pavement was 33 years old. Sections or cubes were sawed from the removed pavement that measured 6 in. square and one of these was tested in compression. Under a load of 5400 lb. per sq. in. a uniform failure occurred. According to our present knowleedge of the water-cement ratio law, and with proportions and materials such as used on this work, this strength is about what should be developed.

The maintenance costs have been very low during this entire 40 year period. For many years the street received no maintenance and as a result the steel tired wagons wore ruts in the longitudinal joints. In later years, the joints have been filled occasionally with bituminous material and this constitutes practically the entire maintenance cost, according to reports.

There has been only a small amount of wear on the middle portions of the streets which is shown by the fact that the small markings made with the hand roller at the time of construction can still be traced. Along the edges of the street, that received their most wear from standing horses during the early life of the pavements, the markings are easily discerned and are prominent enough to photograph.

This pavement at Bellefontaine has been a mecca for engineers from all parts of the world. In 1894 a delegation from Philadelphia inspected the work, returned to Philadelphia and recommended that all court and alley paving in the city be constructed of concrete. The pavement has also received national and international recognition at world fairs and expositions. A block from the street was exhibited at the Chicago World's Fair, in 1893, awarded a gold medal and again shown at the San Francisco Exhibition in 1915. The city now has a total of 84 miles of concrete streets.

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Contract Information Offered

The new Directory of Contractors has just been published by the Bureau of Contract Information, Inc.

This new volume contains a list of those who have filed performance records with the Bureau of Contract Information, Inc. It is available to those responsible in the award of public and private construction contracts.

The service of the Bureau in rendering reports on the performance of contracts by contracting concerns throughout the United States is rendered to those awarding construction contracts without charge, but in exchange for information received on contracts awarded, the Bureau requests performance of contracts and notices of defaults and failures. This service is made possible by the co-operation of surety companies, manufacturers, distributors, and responsible contractors themselves, who have filed their records with the Bureau for the benefit of those awarding contracts.

The Bureau is located in the Securities Building, 729 Fifteenth St., N. W., Washington, D. C.

All architects, engineers and public officials charged with the duty of awarding contracts would quite naturally be glad of an opportunity to inspect the performance records of the contractors with whom they are about to do business. Architects are sometimes deterred from drastically pruning bidding lists by personal friendships; but the greatest influence against architects is brought by owners who insist that bidding lists be amplified by the inclusion of contractors whom architects, of their own accord, would not invite to bid on their work. This brings into issue again the old question as to whether or not an architect, aware that he is in a better position to judge the qualifications of contractors than owners, should insist that he be permitted untrammeled to select his bidders.

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EDITORIAL PAGE OF THE

LOS ANGELES EVENING HERALD Express

AN INDEPENDENT NEWSPAPER

FRANK F. BARHAM, PRESIDENT AND PUBLISHER

No Tampering With Gasoline Tax Must Be Allowed

It's easy to "kill the goose that lays the golden eggs."

That's a truism, but it has had another pertinent illustration here in California in the proposition that $8,800,000 from gasoline tax revenues and about $1,500,000 from truck and bus franchise taxes, now allocated to highway uses, be diverted to the general fund of the state.

That is a vicious proposal. When the gasoline tax was increased from 2 to 3 cents per gallon, the public was assured that the money would all be used for highway construction, improvement and maintenance, until such time as each community should be connected with every other community in the state by an improved road.

That end has not yet been accomplished, but the work already done by the highway commission with the gasoline tax has been of inestimable benefit to the state.

The better the roads, the more people will ride on them. Tourists from other sections come here with the assurance that motoring is a pleasure in California, because of its magnificent highway system.

To divert any of the gasoline tax funds to other purposes would not only break faith with the people, but would also deal a blow at our highway system's growth and development.

It's easy to "kill the goose that lays the golden eggs." That must not be done in the case of the gasoline tax funds in California.

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Oregon Engineer Resigns

Roy A. Klein, Oregon State Highway Engineer, has submitted his resignation to the State Highway Commission, effective March 1. The resignation has been accepted. R. H. Baldock, assistant state highway engineer, has been appointed to succeed Mr. Klein, who will remain with the highway department in an advisory capacity until April 1.

ROCKS OF MT. WARCO

Without regard to good, bad, or indifferent times, industrial progress incessantly continues on its path of progress

Down around the foothills of the staunch old mountain, spring is in the air. The hibernating creatures will soon vacate their comfortable winter homes, the birds will start all over again on their busy task of building their future homes, flowers from the hillside push their tiny sprouts toward the warming sun, and, as the house organ of the W. A. Riddell Company goes on to say, the trees come to life again to bring forth their fruits in season.

Mankind feels its touch, business recognizes the change, because man makes business, business does not make man; so, behold the changes in the foothills of the rock studded mount that means so much to us all. It is a monument to our achievement and the position we occupy on its slopes gauges the pride we have in it, the faith of our hopes and the success we enjoy.

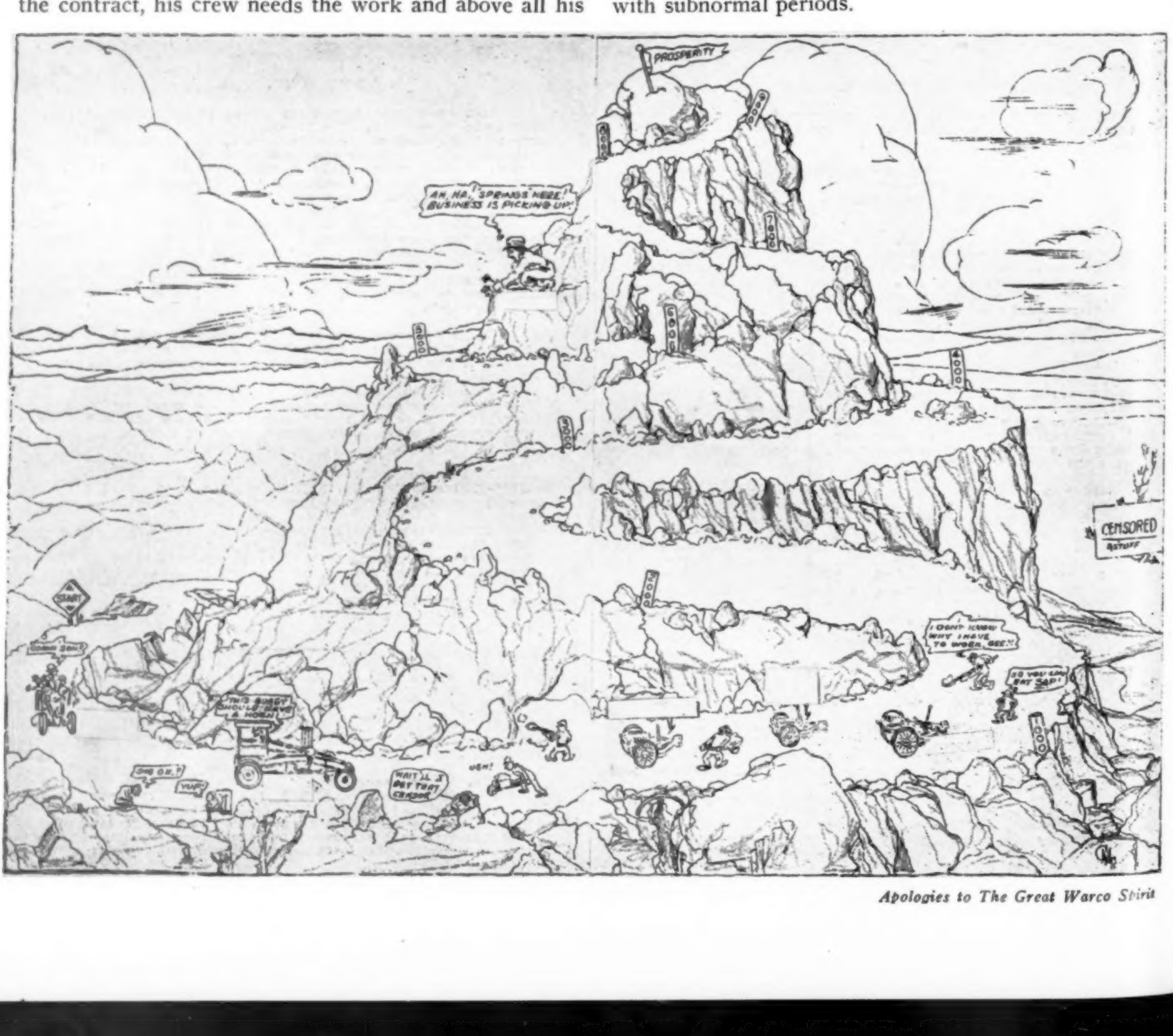
Without regard to good or bad times, industrial progress incessantly continues on its path of progress.

By day or night men everywhere are planning, scheming, plotting and figuring on new enterprises, or how to complete at a profit a project yet to be finished.

Perhaps it is a new highway letting in the near future on which they are concentrating. The contractor needs the contract, his crew needs the work and above all his country needs the development which if arrested retards the growth and prosperity of his community. But should he be the low bidder, perchance he overlooked in his moment of intensely competitive calculations, the condition of his equipment, then comes his greatest anxiety. How to do this job better, more economically and with greater speed.

Naturally then he interests himself in machinery. What is new, how will it work, where to get it and a thousand other mysteries fog his brain. Engineers are designing constantly for improved efficiency in service and facility. Manufacturers are everlastingly building into their equipment the developments of their engineers. Striving diligently to provide more productive equipment, increasing their service and broaden their scope.

Using past experiences as a criterion, the sophisticated producer of machinery of every sort realizes that if he is to cope with competition when the tide turns or the pendulum starts swinging back, he must be in step, as great progress must be made with the advent of ensuing prosperity in order to offset the lost productivity, lagging development, and curtailed progress coincident with subnormal periods.



Apologies to The Great Warco Spirit

Interpretation
OF TESTS ON
BITUMINOUS ROAD MATERIALS

By RICHARD H. LEWIS
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PART II

The purpose of this article is to acquaint engineers and inspectors with the reason for making tests on bituminous materials and what is the practical significance of the various tests. It was run in two parts. The discussion on solid, semi-solid, and liquid asphalts appeared last month. —Editor.

ROAD tars produced from gas-house, coke-oven, water-gas or similar tars are being used in practically the same kind of bituminous road construction as asphaltic products, except hot mix, fine and coarse graded bituminous concrete, and sheet asphalt.

Tars for cold application are designated under the following grades*: Specific viscosity Engler at 40 deg. C. being the measure of the consistency 5 to 8, 8 to 13, 13 to 18, 18 to 25, 25 to 35, 35 to 45. The 5 to 8 grade is only used for priming purposes where the surface to be primed is exceedingly dense. The 8 to 13 grade is more extensively employed for priming applications; and in some rare cases, the 13 to 18 grade has given excellent results as a primer on sand clay surfaces. The more viscous materials or the heavier grades are better adapted for surface treatments. Unless the weather is so cold that the grade 35 to 45 is rendered too viscous to distribute properly over the road surface, even this material can be distributed without heating.

Refined tar for hot application has a consistency of 60-150 seconds as measured by the float test at 32 deg. C. This material can be used in the surface treatment of bituminous macadam, and gravel roads with or without a primer coat to form a wearing mat or carpet. It has been successfully used as binder in premix pavements of the coarse open graded type.

Two grades of tar for repair work have been produced by fluxing refined gas-house, coke-oven, or water-gas tars with suitable tar distillates. The two grades most commonly used are 35 to 60 and 60 to 80 as measured by the specific viscosity Engler at 40 deg. C. These materials have been successfully used to repair surface breaks, holes, and depressions in bituminous macadam and surface treated roads, either by direct surface application followed by cover stone or by premixing with stone and sand. Under favorable temperature conditions the heavier grade may not require heating.

The heavier, more viscous tars are prepared from suitable water-gas tars or from suitable gas-house and coke-oven tars. There are several grades, the measure of consistency of these materials being the float test at 50 deg. C. The usual grades are 100 to 160, 130 to 190, 160 to 220. These products are employed mainly in the construction of bituminous macadam and the consistency specified is governed by climatic conditions and traffic.

Tar Specifications.—The important characteristics of these tars, which determine their suitability for various constructions, are the same for all grades and are as follows:

1. Consistency:
   Viscosity for the cold surface treatment tars and repair tars.
   Float tests at 32 deg. C. for the hot surface treatment tars.
   Float test at 50 deg. C. for the construction tars.
2. Bitumen content:
   Material soluble in carbon disulphide.
3. Amount of residue or pitch together with the volatile and intermediate constituents.
4. The character of the residue as determined by the softening point test.

The specific gravity, while helpful in identifying the source of the tar, if the refined product is not a blend,

*Mr. Geo. Martin, Consulting Engineer, General Tarvia Dept., The Barrett Company, comments, by way of clarification, on specific gravity and grades of material as follows:

(1) It might cause some difficulty if a statement were made that the specific gravity is not an important part of the specifications. We agree that it is not an important part from the standpoint of the use of the material on the road but it is an important factor as an identification of the way in which the material is made up.

(2) You state that Mr. Lewis did not discuss any of the tar materials having a specific viscosity at 40 deg. C. of more than 45. This of course was due probably to the fact that the Bureau of Public Roads specification does not cover materials of this sort. However, a great many of the states have used materials in the range of specific viscosity at 40 deg. C. of 45 to 90. These materials are used quite largely in the construction of road-mix or re-tread surfaces and tars of this sort are an important factor in highway construction work. In this connection there is a movement to change the temperature at which the specific viscosity of these materials are specified and to set the specific viscosity at 50 deg. C. with a range running from 20 to 34 divided into two parts—one 20-26 and another 26-34. This is being done because there is some doubt of the accuracy of the 40 deg. C. test on these stiffer materials and it also saves considerable time in the laboratory.

is not especially important. The density of most fluid asphaltic products and a few semisolid asphaltic products is generally under 1.000; while all tar products, whether fluid or semisolid, used in road construction have densities over 1.000. The higher the free carbon content the higher the density; straight run water gas tars have lower specific gravity values than straight run coke oven tars. Straight gas house tars have the highest densities and show the highest per cent of free carbon. A small amount of water is not considered detrimental in the tars not usually heated, and a maximum of two per cent is usually permitted by specifications.

The viscosity of tars is determined by the Engler viscosimeter. The Saybolt Furol viscosimeter has not, as yet, been adopted for the control of tar products. The tars are more susceptible to change in consistency due to temperature change than asphalt or road oils.

TABLE 8.—SPECIFIC VISCOSITY, ENGLER, OF FLUID TAR AND ROAD OIL AT 3 TEMPERATURES

Material	25° C.	50° C.	100° C.
Tar	195.3	19.4	2.31
Road Oil	111.8	18.6	2.59

The two materials have practically identical viscosities at 50° C., but at 25° C. the tar is considerably more viscous and at 100° C., slightly more fluid than the road oil.

Float Test.—The float test is only used to determine consistency of asphaltic materials when the sample is too soft for the penetration test, or too viscous for the viscosity test. The surface of a tar prepared for the penetration test deforms under the weight of the needle, resulting in an inaccurate penetration value. The penetration test is, therefore, used only on very hard tar pitches not commonly used in road work. The float test is especially adapted to the control of tars because the presence of a large amount of inert material, known as free carbon, does not seriously affect the accuracy of the determination.

There are still some specifications for tars in which the consistency is controlled by the softening point determination. The cube in water melting point method has been, until recently, quite generally used by the tar industry to measure the consistency of the original material and the residue obtained from the distillation test. The heavier grades of tars used in penetration macadam construction are designated, generally, by a float test at 50° C., and, in some specifications, by the softening point by the ring and ball, or the cube in water methods.

Bitumen Content.—The solubility in carbon disulphide is probably of more importance in the testing of tars than for asphalt products. In tars, there is a large amount of inert organic matter held in suspension, which is of no value as binder. This material, which is insoluble in carbon disulphide, is often called free carbon; but the fact that a considerable portion of this substance is soluble in other organic solvents, notably pyridine, indicates that free carbon constitutes only a portion of the organic matter insoluble in carbon disulphide. This material is present in smaller amounts in water-gas tar, and in greater amounts in gas-house tar. Due to its high percentage of free carbon, gas-house tar alone is seldom used in road tars. On distilling and on drying on the road, the free carbon concentrates in the residue, reducing the adhesiveness of the pitch and producing brittleness. It is claimed that in certain types of tar aggregates, the free carbon in the tar acts as a filler in the same manner as limestone dust or portland cement and serves to increase the mechanical strength of the bituminous mixture. In the more fluid grades of road tar, the specifications make no distinction between water-gas tar or blends of water-gas tar with coke-oven and gas-house tar, allowing a maximum of 10 per cent free carbon for cold surface treatment and 15 per cent free carbon for hot surface tretament. In specifying heavy construction tars and repair tars, the engineer may specify water-gas tar or a refined coke-oven or gas-house tar, the former having not more than 5 per cent free carbon and the latter from 5 to 20 per cent free carbon. While many chemists and highway engineers have attempted to set certain limits for allowable amount of free carbon in various grades of tars; there is still considerable difference of opinion as to what amount will prove excessive for satisfactory road behavior.

TABLE 9.—RELATIONSHIP EXISTING BETWEEN FLOAT TESTS AT 50° C. AND SOFTENING POINTS BY BOTH METHODS

	Float Test 50° C.		Softening Point	
	Seconds	Per Cent Free Carbon	Cube in Water Deg. C.	Ring and Ball Deg. C.
1.	270	18.20	49.7	40.0
2.	232	17.20	47.0	36.0
3.	198	22.60	44.5	35.0
4.	180	13.26	42.5	33.7
5.	159	11.84	41.0	32.7
6.	140	2.40	40.5	29.0
7.	122	3.90	39.5	28.0
8.	111	13.90	37.0	26.7
9.	100	3.60	34.5	22.5
10.	93	2.22	34.0	21.5

Distillation.—The distillation test is generally made according to the standard A. S. T. M. method, which provides for the following fractions:

0—170° C.
170—235° C.
235—270° C.
270—300° C.

The distillation results are reported on a weight basis. The total amount of distillate to 300° C. is greatest in the cold surface treatment materials and least in the heavy construction tars.

For cold application materials, the amount of distillate should be well distributed in all the fractions and the resulting pitch residue should not have too high a softening point. These materials being used in mat and carpet forming treatments should not become brittle by too rapid drying or by developing too hard a pitch residue, yet sufficient cementiousness should develop to hold the cover stone.

Hot surface treatment materials, since they have sufficient binding value at time of application, should not have a high percentage of distillates in the lower fractions and the residue should not have a high softening point.

Cold patch or repair tars are normally pitches cut back with fairly volatile distillate. The lower fractions should show a considerable proportion of the solvent distillate, and, since these products are usually used in prepared mixes, a harder pitch residue may be desirable.

In the construction tars, the amount of distillate in the first two fractions should not be great. This material has sufficient body to adequately bind the mineral aggregate and since the bulk of the material coating the stones is not in direct contact with light and sun, the softening point of the pitch residue need not be as low as in the surface treatment tars.

Many tar specifications provide a maximum limit for per cent of distillate up to 170° C. and a maximum softening point for the residue from distillation. In case of tars being used as primes, minimum values covering these two requirements might prove advantageous

in those cases where the time of drying of the primer on the road should be hastened.

Analyses of typical road tars are given in Table 10.

Bituminous Emulsion

The earliest use of bituminous emulsions in this country was as dust palliatives. Fluid petroleums were emulsified, and the emulsion further diluted with a considerable volume of water. This procedure was generally accomplished in the tank of the old type water cart and the roadway sprinkled to allay the dust. The macadam roads of many park systems were treated in this manner.

For many years asphaltic emulsions have been used in maintenance work for the repairing of breaks and holes in surface treated roads and bituminous macadam roads. More recently these products have been employed in the cold surface treatment of various types and in the construction of roads of the penetration macadam type. Some construction by the mixed-in-place method has also been done. The advantages claimed for asphaltic emulsions are the elimination of heating costs on the job to render material sufficiently fluid for the required purpose, and the lower cost resulting from the use of water with emulsifier for thinning the asphalt instead of expensive volatile solvents.

In the process of maufacturing emulsions, asphalts are agitated in water at high temperatures mechanically, or by steam in the presence of an emulsifying agent, such as soap, clay or other emulsifiers. In some cases, caustic alkali and a fatty acid are added directly to the asphalt and hot water to produce the soap, which in turn forms a film on the surface of the minute particles of bitumen. The function of this soap film is to insulate the particles of bitumen by counteracting the molecular forces which tend to reunite the dispersed particles causing coagulation. The more minute the oil particles, the more permanent the emulsion; and asphalt emulsions, at the present time, remain in a state of complete emulsification for longer periods, and are able to withstand lower temperatures than the earlier emulsions on the market.

Characteristics.—The important characteristics of an asphaltic emulsion, which can be determined by laboratory tests are:

1. Permanency
2. Homogeneity
3. Viscosity
4. The rate of break
5. Water
6. Amount and character of asphalt

The permanency of an asphaltic emulsion cannot be accurately measured, but some comparative data can be secured which will form some guide as to storing properties of a given grade. After allowing a definite quantity of emulsion to stand in closed container, a determination of the asphalt content of the upper layer (one-tenth of total volume) and of the lower layer of equal volume, will indicate whether or not the material is undergoing change.

The homogeneity may be determined by passing a predetermined quantity of emulsion over a wire screen and weighing the residue held by the screen. There should be no appreciable residue remaining on the screen.

The rate of break is an important factor in the selection of an emulsion for a particular purpose. Surface treatments and penetration macadam require a material which will rapidly lose its water and quickly develop the adhesive properties possessed by the asphaltic material present in emulsion. Emulsions suitable for repair work must have a retarded break, so that the material can be mixed with mineral aggregates, handled and placed in the road before the emulsion is broken. The ideal break for mixed-in-place construction will depend to a great extent on the character and fineness of the material aggregates present in the road surfaces.

Rate of Break Tests.—There are three methods which have been considered for determining the rate of break. The filter paper test, which records the time in seconds necessary for the water present in the emulsion to travel from a ring of the poured emulsion to an outer concentric circle drawn on the filter paper. The test is not easily checked because of the non-uniform texture of the filter paper and the varying humidity of the laboratory; and is unsuitable for the heavier grades of emulsions.

The McKesson basket test has possibilities, but the surface quality and size of stone used could not readily be made standard for the entire country. Stone is coated with bituminous emulsion and after a stated period the emulsion which has not broken is washed

Table 10.—Analyses of Typical Road Tars

Material	Specific gravity 25°/25° C.	Spec. visc. Engler 40° C.	Float Test 30° C. Sec.	Float Test 50° C. Sec.	Softening point (R&B) Deg. C.	Carbon Disulphide Solubility: Soluble Per cent	Org. insol. Per cent	Inorg. insol. Per cent	Distillation by Weight: Up to 170° C. Per cent	170° C. to 235° C. Per cent	235° C. to 270° C. Per cent	270° C. to 300° C. Per cent	Res. over 300° C. Per cent	Softening point of res. (R&B) °C.
Cold surface treatment tar Water-gas tar	1.096	15.5	....	....	....	99.04	0.93	0.03	0.23	8.63	16.73	10.45	64.01	35
Cold surface treatment tar Low carbon content (a)	1.131	12.2	....	....	....	96.03	3.90	0.07	2.21	7.38	11.00	7.90	71.60	43
Hot surface treatment tar Water-gas tar	1.145	.....	138.5	58.5	....	98.00	1.73	0.27	0.0	1.20	8.84	9.79	79.40	52
Hot surface treatment tar Refined tar	1.208	.....	189	62.0	....	88.73	11.27	0.0	0.0	0.67	7.18	5.64	86.20	49
Tar for repair work Water-gas tar	1.128	66.2	....	....	....	98.22	1.64	0.14	0.82	7.18	6.59	8.78	76.46	41
Tar for repair work Refined tar	1.168	53.0	....	....	....	86.40	13.56	0.04	1.72	12.07	4.54	4.21	77.31	57
Tar for construction Water-gas tar	1.156	.....	677	141	34	96.74	2.99	0.27	0.0	0.0	2.60	5.98	91.72	48
Tar for construction High carbon tar	1.242	.....	1,167	157	32	80.54	19.33	0.13	0.0	0.41	3.64	5.30	90.50	57

(a) Material contained 2.1 per cent water. Distillation and solubility on water free basis.

off. The asphalt from that portion of the emulsion broken is determined by drying and weighing the stone.

The calcium chloride test, developed by Mr. Meyers of the New York State Highway laboratory depends on the fact that a solution of 35 c.c. of .02 normal calcium chloride will cause about 100 per cent coagulation of the asphalt in an emulsion which has no soap emulsifying agent present. As the amount of soap emulsifying agent is increased, the coagulating power of the same quantity of .02 normal calcium chloride is reduced.

It is maintained by those thoroughly familiar with emulsions that the rate of break is controlled to a great extent by the amount of emulsifying agent present in the emulsion. The more emulsifier present the slower the break. Whether or not this calcium chloride test will give comparable results, when an emulsifier other than soap is used, is problematical.

The viscosity is of importance when the material is to be applied by distributor, or when penetration of void space is desired. A free flowing material is necessary for penetration and surface treatment construction. A low viscosity is not as essential for use in mixes and repair work.

The fluidity of an emulsion is, to a certain extent, dependent on the water content of the emulsion. The amount of water in those emulsions used in cold patch work is less and the asphalt content more than in those products applied directly to the road. It is always advisable to make a determination of the amount of water in the product, since it is the amount and quality of the emulsified asphalt, as pure bitumen, that determines the value of the emulsion for a particular purpose.

After dehydrating and determining the water, the residual asphalt is subjected to the usual tests for asphaltic material. The recovered asphalt should possess characteristics substantially the same as those usually found in materials used in the unemulsified state in similar kinds of construction. The asphalts in emulsions, however, are usually of the softer grades.

Typical tests on asphaltic emulsion are given in Table 11.

Bituminous Aggregates

The testing of bituminous aggregates and bituminous rocks involves the determination of the bitumen content by some form of extraction. The mechanical analysis or grading of the mineral aggregate is also made. Often the density of a cut out section from the finished roadway is desired, in order to know if the pavement has received maximum compression under the roller. If the densities of the constituents of the mix have not already been determined, it is necessary to run these tests. These values are necessary to determine first, the maximum possible density and in turn, the per cent of voids existing in the sample from the roadway.

If the bituminous binder is unknown, it is often desirable to run tests on the residue obtained by distilling off the solvent used in extraction, and removing the last traces of solvent by evaporation at elevated temperature. Where tars, high in free carbon, or native asphalt, high in mineral matter, have been used in the paving mixture, the recovered bitumen does not truly represent the original amount of asphalt or tar used in the mix, but does represent the amount of actual bituminous binder.

A number of tests have been devised to measure the relative stability of various bituminous mixtures. It has not been definitely proven that any of these stability determinations accurately indicate the relative road behavior of the many different types of bituminous surfacings which are being used in roads today. For the coarser graded and the more open graded mixes, at least, no satisfactory method of determining their resistance to displacement has been developed. The researches of Hubbard and Field, Skidmore and Abson, Emmons and Anderton, Milburn and Ulman and other investigators on bituminous mixtures should prove interesting and instructive to both the testing and highway engineer.

The laboratory control of bituminous road materials is by no means as thorough and complete as the bituminous chemist desires that it should be. A satisfactory means of measuring the adhesiveness or cementing value of various asphaltic and tar binders must be found. The behavior of bituminous materials with mineral aggregates of different surface textures and physical properties should be carefully investigated. The effect of moisture and weathering is more pronounced with some fluid bitumens than with others, and the discovery of the underlying cause will do much for the continued success of the low-cost roads in which these fluid materials play such a prominent part. All these problems are a challenge, both to the chemist and engineer, and their solution will require close cooperation between the field forces and the laboratory.

Table 11.—Tests on Asphaltic Emulsions

Material Used for	Surface Treatment and Penetration Macadam		Repair Work
Specific gravity, 25°/25° C.	1.001	1.021	1.025
Specific viscosity, Engler, 50° C.	1.54	3.70	173.9
Screen residue (per cent)	.05	.02	.06
Filter paper break (seconds)	85	125	600
Calcium chloride break, percentage of asphalt	94.2	14.0	6.6
Percentage of water	46.0	37.0	29.0
Percentage of asphaltic residue	54.0	63.0	71.0
Tests on asphaltic residue:			
Specific gravity, 25°/25° C.	1.003	1.029	1.036
Penetration at 25° C.	191	139	138
Softening point (° C.)	38.4	46.6	47.6
Ductility 25° C. (cms.)	110+	110+	62
Soluble in carbon disulphide (per cent)	98.91	99.27	98.29
Organic matter insoluble (per cent)	0.73	0.17	0.38
Ash, by ignition (per cent)	0.36	0.54	1.33

▼

Truck Terminal Operations Subject to Ohio Regulation

The owner of a freight terminal who furnishes terminal facilities for truck lines and makes contracts for the transshipment of goods in motor vehicles was held by the Supreme Court of Ohio to be subject to regulation by the Public Utilities Commission as a motor transportation company.

The decision was in the case of Larkin et al. v. Public Utilities Commission. The syllabus by the court follows in full text:

Under section 614-84, General Code (113 Ohio Laws, p. 484), a person who owns a motor freight terminal, furnishes terminal facilities, and makes contracts for hire for transshipment and routing of property from his terminal, in motor-propelled vehicles, for the public in general, over any public street, road, or highway in this State, is engaged in the business of carrying or transporting property and in providing and furnishing transportation service for hire, and constitutes a motor transportation company within the purview of the Motor Transportation Act.—*U. S. Daily.*

A Discussion Concerning

ADHESION TENSION *in Asphalt Pavements*

Its Significance and Methods Applicable In Its Determination

By VICTOR R. NICHOLSON
Engineering Chemist, Bureau of Streets, Chicago, Ill.

Second Installment of Three

Mr. Nicholson, in this article, explains the theories and methods of measuring adhesion tension and cohesion in liquid-liquid, liquid-solid, and solid-solid systems. Surface tension plays an important part in these measurements and is clearly explained.—Editor.

IN the first installment of this paper, two pavements were described; one a sheet asphalt made with a coarse concrete sand, and the other a surface laid with rock asphalt mined and milled in Kentucky. The asphalt on the coarse concrete sand in the sheet asphalt came off under the influence of water and traffic, while the bitumen in the rock asphalt stayed on the grain. It is therefore proper to say that the asphalt did not adhere to the coarse concrete sand, whereas it did adhere quite well to the aggregate in the rock asphalt.

Richardson, in his "Treatise on Asphalt Pavements," citing his experience in England, stated that on using a sand containing much coating, the asphalt pavement laid with it, disintegrated in a short time, due to the wet climate. The same thing probably happened in the case mentioned by Dow in Denver, where a pavement laid with a crushed weather granite disintegrated in a short time. As related by Richardson, the pavement in England disintegrated due to the action of the water on the colloids surrounding the grains. Either the colloidal material was not completely covered by the asphalt, or else the colloids prevented the adhesion of the asphalt to the body of the sand.

In view of these observations, *it would be highly desirable to devise methods which would give reproducible relative or absolute values for the adhesion of asphalt to aggregates* so that this quality of a binder in a mixer could be evaluated.

In America, the study of adhesion of asphalt to aggregate has not received the thought and consideration it deserves, but its importance is generally recognized in Europe. A part of Clause (a) in the Third Conclusion on Bituminous and Asphaltic Roads of the Fifth International Road Congress held in Milan, Italy, in 1926, reads as follows: "The Congress, however, expresses the desire that a practical method may also be found of measuring the adhesion of a bituminous binding material to an aggregate, and that a complete study should be made of the action of the very fine mineral matter incorporated in the bituminous binders, on the so-called asphaltic characteristics of the binding material itself." In another part of the report containing the Conclusions, the following sentence appears: "But so far, the test for stability under the action of meteoric water, does not seem to be perfect."

Before describing the work that has been done in America on this matter the following definitions will be given at this time:

Adhesion, as used in this paper, is defined as that physical property or molecular force, by which one body sticks to another of different nature. Thus the holding of asphalt on sand is called adhesion.

Adhesion tension, is defined as the degree of adhesion by which one body sticks to another of different nature. This can be calculated in terms of physical units of force as given hereafter.

Cohesion is defined as that force by which molecules of the same kind or of the same body are held together, so that the body resists being pulled to pieces. Thus we can say that an asphalt such as Mexican, coheres to itself or any other asphalt, but adheres to sand or limestone. Like adhesion tension, cohesion can be calculated in terms of physical units of force.

In an asphalt pavement, it is very desirable that the asphalt should adhere as well as possible to the aggregate. If this adhesion is of a low order, it will make the asphalt come off under the action of the traffic and rain. Pavement is very liable to crack, and these cracks once formed will never heal up under the action of this same traffic. Depending on the ability of the water to get down into the pavement, in other words the permeability of the pavement, the adhesion will to a very large extent determine the life of the pavement. If possible, the adhesion tension of the asphalt for the aggregate used in the pavement, should be at least the same as or greater than that shown by water for this same aggregate. In the case of a pure silica aggregate, it should be at least 82 dynes per square centimeter, which is the adhesion tension between water and pure silica.

It is very evident that the coated mineral grains must stick together to form a good pavement, therefore, the asphalt must possess sufficient cohesion to do the work desired. The amount of cohesion in the asphalt will determine the physical stability of any series of asphalt mixtures made with same mineral aggregate. Thus an asphalt showing low cohesion will give lower stabilities

than one showing higher cohesion. The cohesion is governed by the penetration of the asphalt to a certain extent, the softer the asphalt in the same chemical series the less the cohesion. While penetration has a relation to cohesion in the same chemical series, it does not necessarily imply that asphalts from different sources, showing the same penetration, are necessarily the same in cohesion. It is very important that the cohesion should be less in dynes per sq. cm., than the adhesion tension in dynes per sq. cm., for the reason that if it possesses more cohesion than adhesion, it will pull off the sand grains in temperature contraction strains, which will not be remedied on the return of warm weather. When it is considered that cohesion is an inherent property of liquids, it can be seen that it is always easier to make asphalt stick to itself, than it is to make it stick to some other foreign body.

In this country several tests for determining the adhesive properties of asphalt have been devised, but none of them in their original form test the asphalt in connection with the aggregate to be used in the paving mixture. It is my assertion that any test of this sort, which does not take into consideration the different mineral aggregates, is liable to give some very misleading results.

The measurement of ductility was for a long time, and perhaps even today, believed by some to be a measure of the adhesion of asphalt. This belief, however, is erroneous, for I believe it is generally recognized that the harder, and therefore less ductile, an asphalt is in a given series of asphalts, the better it will stick to the sand; whereas, if ductility were the deciding factor, the reverse would be true. Ductility, therefore, is only a measure of the fluidity of the asphalt, at the temperature at which this test is run. The ductility test has been in for a lot of criticism during the last ten years, and its elimination from the series of tests to be run on asphalt was seriously considered at the 5th International Road Congress, held in Milan in 1926. The consensus of opinion at this meeting was that it governed the elastic properties of asphalt especially at low temperatures.

Osborne, in California, determines adhesiveness by using two concentric cylinders made of metal, which fit into each other. The stationary inner cylinder, 1.995 in. external diameter, is hollow and is maintained at a temperature of 77 deg. F., by a stream of water entering and leaving same by two connecting tubes. The movable outer cylinder or collar, 2.000 in. in diameter and 2 in. wide, is caused to revolve on the inner cylinder with a uniform layer of bituminous material to be tested in between, by being wound with a cord attachment to a 3 kg. weight. The adhesive value of the bitumen being tested is measured by recording the length of time required for three complete revolutions of the collar. It is very doubtful in this test whether adhesion is really being measured, as the speed of rotation of the collar will be determined by the cohesion of the bituminous material.

The Brown Adhesive Test, really only measures the cohesion of the asphalt, so will not be discussed here.

Kirschbraun determines the force required to pull a wooden ball, covered with a piece of silk immersed in the sample of asphalt being tested and held in a box which is stationary on the apparatus. It was proposed to the 5th International Road Congress that this method be used as a standard in the determination of adhesiveness, after first substituting a cube of the mineral matter to be used in connection with the asphalt in the production of the paving mixture, for the wooden ball ordinarily used. Except in cases where the adhesiveness of the asphalt is less than the cohesion of the asphalt, the results obtained are really dependent on the cohesive properties of the asphalt.

Another test determines the force required to pull apart two brass blocks, which have been cemented together with the asphalt to be tested. The same objection exists to this test as to those mentioned above.

Kirschbraun, has also designed and used the so-called Cementation test, in which he determines the work required in kilogram-meters, to pull apart a standard ductility briquette of asphalt to be tested, almost always at a temperature of 41 deg. Fahr. If this method could be changed in any way so as to prevent the asphalt from stretching before breaking, then this method would be a measure of the cohesion of the asphalt.

While the asphalt chemists have been trying to measure adhesion, the physical-chemical laboratories of some of our larger universities have been busy devising methods for determining adhesion tensions in liquid-liquid and liquid-solid systems. Thus Prof. Harkins at the University of Chicago, with his associates has been pioneering in the field of liquid-liquid systems and has derived much data along these lines. Prof. F. E. Bartell and associates at the University of Michigan, has been working on liquid-solid systems along lines of value to asphalt work. Freundlich in his book on "Colloid and Capillary Chemistry" also goes into this matter on a rather extensive scale.

According to all work done along purely physical-chemical lines, in order to show how a liquid sticks to a solid, a measurement of the surface tension of the liquid is essential. There may be objection in some quarters to the application of liquid-solid reactions to asphalt which some people consider as a solid or at least a semi-solid. However, when it is considered that most paving asphalts have a melting point by the ball and ring method of 130 deg. F., above which temperature the asphalt is definitely a liquid, and whereas temperatures of 140 deg. F. were recorded at the Arlington test pavement, it is obvious, of course, that the asphalt on the grain at this temperature was a liquid; so therefore it is my opinion that liquid-solid reactions will hold for asphalt instead of solid-solid reactions. As surface tension measurements are so important in the measurement of adhesion tension in liquid-solid systems an explanation of what it is, is in order at this time.

A molecule is defined as the smallest physically indivisible unit of matter. Molecules of a liquid, are conceived as being surrounded on all sides by a field of force. This field of force determines the attraction of the molecule for its neighbors. As long as the molecule is down in the liquid, this attraction for its neighbors is the same in all directions. However, as the molecules approach the boundary made by the liquid with a gas, such as air, then the upper parts of the molecular fields of force have nothing to be attracted to, so the molecules are attracted to each other stronger laterally on the surface, thus creating a tension in same. This is the force which tends to make the drops of a liquid in air, round in shape. Harkins gives a practical example of what surface tension is as follows: "If a camel's hair brush is dipped into water, the hairs remain apart as if they were dry and in the air, but when the wet brush is pulled out of the water, the pull of the surface tension of the water, binds all of the hairs compactly together." It can also be very beautifully demonstrated by means of the Maxwell Frame shown in Fig. 1. This consists of a wire frame *ABCD*,

in which a movable slide, *CD*, slides parallel with *AB*. If we fill the rectangle, *ABCD*, with a film of liquid by vertically dipping the frame in same this will contract and raise the wire, *CD*. If now we put a little weight on pan as shown, it is found that by increasing or decreasing this weight the position of the slide, *CD*, will be high or low in the frame, according to the weight in the pan. This particular weight in any given position, just balances the surface tension of the films, and as

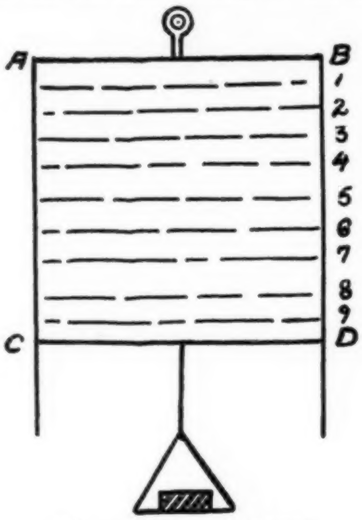


Fig. 1.—Maxwell's Frame

two surfaces are exposed the weight on the pan is equal to twice the effect of the surface tension. If now the wire is allowed to go back close to position, *AB*, as at 1, by removing the weights and then the position of *CD* brought down to say, No. 9, by the addition of proper weights, it is evident that the work done by these weights is that required to balance the surface tension; this work, and therewith the free surface energy, is obviously the greater, the greater on one hand the adjusted weight and on the other hand, the surface, *ABCD*. Hence,

Free surface energy equals surface tension times area of surface, or surface tension equals free surface energy divided by area of surface. It is thus numerically equal to the mechanical work which must be done in generating unit surface.

Surface tension on ordinary liquids can be determined by counting and weighing drops of same under standard conditions. Thus a liquid giving big drops when falling from a capillary tube at a certain temperature will have a higher surface tension than one giving small drops. It can also be determined by the rise in capillary tube method and by measuring the force required to remove a ring placed in the surface of the liquid. The before mentioned methods for the determination of surface tension of asphalt, are inapplicable unless the asphalt is heated to bring it to a fluid condition, all performed under careful thermometric control. It has been found that surface tension of a liquid is greater the less the temperature so it is always necessary to state at what temperature the surface tension was determined.

The surface tension of liquids, unless specifically stated, is determined against air. To be absolutely correct, the surface tension of a liquid should be determined against its own vapor, but the difference is usually less than ½ per cent. The surface tension of one liquid in the presence of another liquid or a solid instead of air is called "interfacial tension" and it may differ considerably from the surface tension against air. The adhesion between two liquids or between a solid and a liquid is governed to a large extent by the interfacial tension between them. Thus, a liquid showing high interfacial tension against another liquid will not adhere as well as a liquid showing a lower interfacial tension against it. The same condition holds between solids and liquids. Interfacial tension can be demonstrated by taking an ordinary Petri dish and filling it with water to within a ¼ in. of the top. Clean an ordinary Gillette safety razor blade in some carbon disulphide and dry with a cloth. On placing this blade flat on the surface of the water it will float and can only be submerged in the water by pushing it down with the finger. Remove the blade from the water and dry and instead of water in the dish put some carbon tetrachloride which is 1.50 times as heavy as the water into same. The blade will not float on the surface but will quickly submerge. The reason for this phenomenon is that the interfacial tension between the water and the steel blade is sufficient to overcome the difference in the densities of the water and the steel. In the case of carbon tetrachloride, the interfacial tension between the liquid and the steel is not sufficient to overcome the differences in the densities of the liquid and the solid.

The measurement of the surface tension of a liquid assumes added importance in view of the fact that the work of cohesion of the liquid at any given temperature has been proven to be numerically equal to twice the surface tension of the liquid at the same temperature. *Nellensteyn, in Holland, and E. Hatschek, in England, in his book on "Surface Tension and Surface Energy" have shown that the surface tensions of two liquids even though of the same series has a profound influence on the solubility of the liquids in each other.* It can thus be seen that this determination is an important one to make from several points of view, and

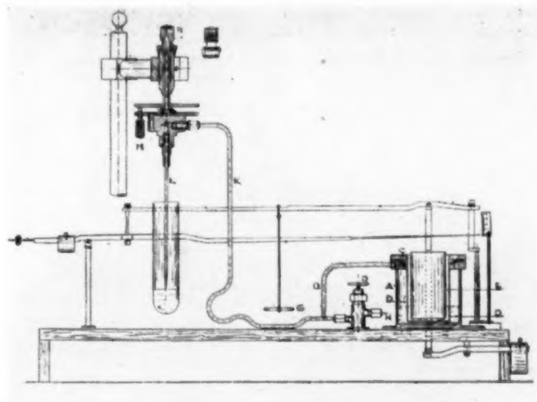


Fig. 2.—Jager's Bubble Pressure Surface Tension Apparatus

it is to be regretted that no data of this sort are available in the literature on asphalt.

Working along a different line of asphalt investigation, Nellensteyn in Holland, in order to determine the surface tension of asphalt, uses the apparatus shown in Fig. 2, where this property can be determined on any asphalt at any temperature above a minimum, which varies with the asphalt being tested. This is known as the modified Jager Bubble Pressure Method. The asphalt is put in the bottom of the test-tube shaped vessel which is maintained at any desired temperature by suitable means. A capillary tube 0.6 mm. in diameter composed of a platinum-rhodium alloy, is so regulated by means of a set screw, that the tip is introduced into the surface of the asphalt to a depth of 1/100 mm. The maximum pressure of a gas such as nitrogen just suf-

ficient to cause bubbles of gas to escape is used in a formula to determine the surface tension. The results of some of Nellensteyn's works are shown in Fig. 3. The parts in the solid lines represent the results on three types of bitumen, obtained by this researcher. It can be seen from an inspection of the curves that surface tensions of all three types of bitumen tested, gradually increase with decrease in temperature, until a certain point, which he calls the notch point, is reached when the surface tension increases much more rapidly. It is

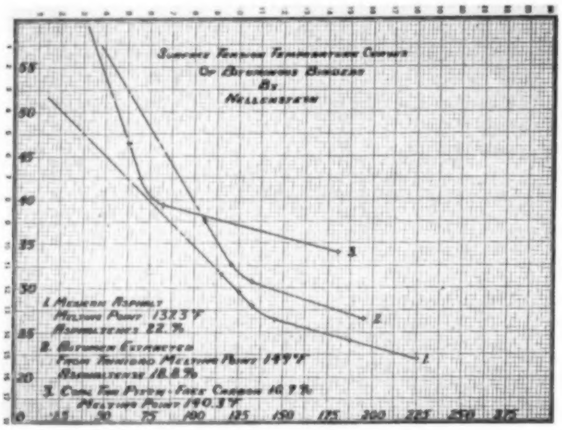


Fig. 3.—Nellenstyne's Surface Tension Temperature Curves

believed by some investigators in this line of work, that the reason for this sudden increase in surface tension below a certain temperature, is caused by a solidification of the asphalt below these temperatures. If the slope of Curve 1 remains constant, as I have indicated by dotted lines, then the Mexican asphalt at ordinary temperatures will have a surface tension less than water which is 72 dynes per square centimeter. On the other hand, both the extracted bitumen from the Trinidad asphalt and the plain coal tar, runs at ordinary temperatures considerably higher than water in surface tension.

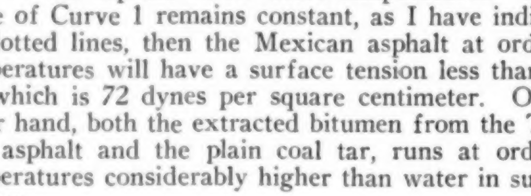


Fig. 4.—Adhesional Wetting

There are two general theories prevalent as to why a given solid is wetted by a liquid. The first and best established theory is that the wetting or non-wetting of the liquid is determined by the magnitude of the angle of contact which the liquid makes with the solid. There is some difference of opinion as to the size of the angle of contact which will prevent wetting. The other theory, advocated by Bancroft, is that wetting is solely an absorption phenomenon. The idea of this theory is, that when a liquid wets a solid in the presence of air the liquid must be more strongly absorbed than the air and therefore must displace it on the solid. This theory does not state how this is performed, so it is very probable that it is only a general statement of what the first theory specifically states. Therefore, in order to reconcile as much as possible all the different points of view concerning wetting, Bartell has analyzed wetting phenomena.

According to Bartell, when a solid is wet by a liquid, it may do it in three different ways, i.e. by adhesional wetting, spreading wetting, or immersional wetting.

Adhesional wetting is best illustrated in Fig. 4 where a solid of unit facial area having a surface tension S_1 is shown away from the same unit facial area of liquid having a surface tension of S_2. The total surface tensions or free surface energy of these two materials can then be represented by $S_1 + S_2$. If however, the solid is brought down in contact with the liquid, as shown at the right of the figure, then the two surface tensions on the solid and liquid will disappear, and in its place an interfacial tension represented by S_{12} will appear. The change in surface energy due, to contact of the two substances will be represented by $S_1 + S_2 - S_{12} = W_a$, where W_a represenets the work of adhesion.

For convenience, as will be seen later, this equation can be changed to read as follows:

$S_1 - S_{12} + S_2 = W_a$, which is known as equation (1.)

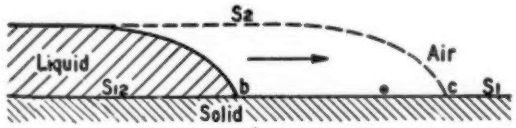


Fig. 5.—Spreading Wetting

In spreading wetting as illustrated in Fig. 5, the work of spreading can be determined, by considering a drop in contact with solid surface *ab*. Assume that the liquid is caused to spread through distance *bc*, and that in so doing the unit area of surface becomes covered. The free surface energy changes which occur are:

(1) Disappearance of unit area of solid-air interface (energy decrease S_1);

(2) Formation of unit area of solid-liquid interface (energy increase S_{12});

(3) Formation of unit area liquid-air interface (energy increase S_2).

The free surface energy changes or the work of spreading, therefore equation (2) is

$S_1 - S_{12} - S_2 - W_s$ where W_s represents work of spreading.

In immersional wetting, the work is that done in converting a solid-air system into a solid-liquid system.

Consider a solid of unit surface in air. Its free surface energy or surface tension is S_1. Immerse the solid in a liquid: its free surface energy is now the interfacial tension with the liquid or S_{12}. The change in free surface energy, or the work of immersion, equation (3), is:

$W_1 = S_1 - S_{12}$.

Equations 1, 2, and 3 represent the amounts of work the liquid-solid systems will do by themselves without aid from the outside, in adhesional, spreading, and immersional wetting. The amounts of work here represented contribute to the heat of wetting when a finely divided solid or powder is immersed in a liquid such as water. The other factor governing the amount of heat generated, includes the latent heat of surface formation, concerning which, there is some question.

It can be seen from an inspection of these equations, that most work is performed in adhesional wetting, followed by immersional, and spreading wetting in the order of their magnitude. It can also be seen that the difference between adhesional work, immersional work, and spreading work is equal to the surface tension of the liquid. For this reason it can be seen that a high surface tension aids in adhesional wetting, has no bear-

ing on immersional wetting, and actually retards spreading wetting. It can also be seen that the smaller the surface tension of the liquid the less the adhesional wetting work but the greater the amount of spreading work. This is one of the reasons for heating up asphalt before spreading in the asphalt mixture. There are only a few examples of adhesional wetting reactions used in the industries, the chief one being a glued joint where one surface is covered with an adhesive and the other part of the joint pressed up to it. The spreading of road oil on the street is a very good ex-

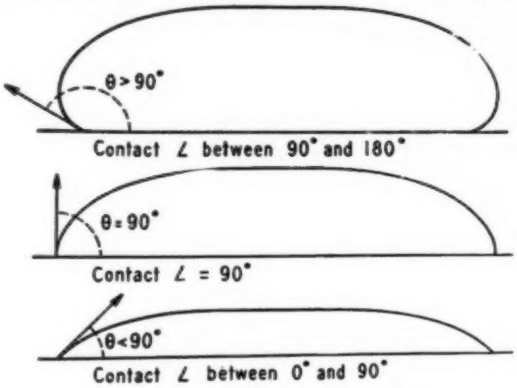


Fig. 6.—Typical Angles of Contact

ample of spreading wetting, and the coating of agricultural machinery with paint by immersing them in a tank of paint, is an example of immersionable wetting.

It is rather hard to state what type of wetting occurs in an asphalt mixer, as the amount of asphalt being used and the type of the pavement being mixed will have a bearing on it. Thus in making a rich mix there will be more adhesional wetting than in a lean mix. A pavement composed of large stones will be coated almost entirely by spreading wetting. In all cases it will consist of more or less of each type, with spreading wetting predominating in sheet asphalt. In any case, however, the total amount of work done by the asphalt in connection with the aggregate will on an average be equal to the work of immersion.

The amounts of work done by the three systems will be governed also by the angle of contact which the liquid makes with the solid, as will be shown hereafter.

A drop of any liquid placed on a solid, can assume any one of five different shapes, three of which are shown in Fig. 6. It can form a drop with an angle of contact of 180 deg. with the solid, when no adhesion is possible with the solid. It can show a contact angle between 90 and 180 deg. as shown in Fig. 6, when the adhesion will be of low degree, actually less than one-half the force of cohesion liquid-liquid. When the solid-liquid contact angle is equal to 90 deg., it has been shown that the force of adhesion is equal to one-half the force of cohesion of the liquid molecules for each other. When the solid-liquid contact angle is between 0 and 90 deg., the force of adhesion, solid-liquid, is greater than one-half tthe force of cohesion, liquid-liquid, but never equal to it. The other shape the drop may assume is to spread over the solid with a zero liquid-solid contact angle, when it will possess an adhesion tension, between liquid and solid, always greater than the cohesion liquid-liquid. Liquids will tend to spread out in thin films over solid surfaces only when the angle of contact is zero. Asphalt applied to aggregate, as mentioned before, is to a large extent a spreading wetting phenomenon; therefore, it is very desirable that the asphalt should spread on the aggregate with a zero angle of contact.

The angle of contact, liquid-solid, illustrated above, assumes added importance in view of the fact that Freundlich, in his book on Colloid and Capillary Chemistry, has shown that adhesion tension, which is a measurement of the degree of adhesion of a liquid for a solid, is equal to the surface tension of the liquid multiplied by the cosine of the angle of contact which it makes with the solid, or, equation (4).

$$A_{12} = S_2 \cos \theta$$

where A_{12} is the adhesion tension between solid, S_1, and liquid, S_2, and θ is the angle of contact between the liquid and solid as shown in Fig. 6.

In the case of asphalt applied to various minerals, no data are available as to whether the asphalt forms an angle of contact or not. In case it spreads with a zero of contact, then the foregoing equation becomes changed and is as follows:

$A_{12} = S_2 K$, where K is a constant always greater than unity, equation (5).

Another formula, equation (5)A, for adhesion tension, derived over a hundred years ago, and proven to be true since that time by many investigators, is:

$$S_1 - S_{12} = S_2 \cos \theta$$

But $$A_{12} = S_1 - S_{12}$$

From equations 5A and 5B it follows, $A_{12} = S_1 - S_{12} = S_2 K$ to get equation (6), where S_1, S_2 and S_{12} represent, respectively, surface tension of solid and liquid, and interfacial tension between liquid and solid. In the case of solids neither S_1 nor S_{12} can be determined. However, it can be seen from this formula that the less the interfacial tension, the greater the adhesion tension. We also know from liquid-liquid study, that the more the two adhering materials are like each other, or the more they are attracted to each other, the less the interfacial tension between them.

Until the advent of Bartell's work, the adhesion tension could only be determined for liquids showing an angle of contact with the solid. The big task which Bartell accomplished was the determination of the angle of contact which the interface between two liquids made with a solid.

The determination of the angle of contact between a single liquid and a solid is done according to the formula for capillary rise of liquids, which is equation (7),

$$\cos \theta = \frac{rhdg}{2S.}$$ where r is radius of capillary tube, h is the amount of rise, d is density of liquid, g is the influence of gravity, and S is the surface tension θ of the liquid.

The determination of the angle of contact of a liquid with a material such as glass in a capillary tube, is a simple experiment in physical chemistry. Knowing the density and surface tension of the liquid, it can be seen that all that is involved in a determination of this kind is a measurement of pore radius of the tube and the height to which the liquid rises in the tube. Both of these determinations can easily be done in the laboratory by optical measurements. The determination of the contact angle between a liquid and a solid such as crushed silica, however, is more difficult.

Bartell has shown by data obtained in his laboratory, that when portions of a powdered rigid solid are compressed under a uniform pressure, membranes or briquettes are formed whose interstices are in effect capillary pores of approximately circular cross-section, and of fairly constant radius. The effective radius of these pores can be measured with equal accuracy by the capillary rise method cited above or by Poiseuilles' formula.

Using the capillary tube method, Bartell compresses powdered material of uniform particle size in brass displacement cells of the same size and shape as those shown hereafter in the determinattion of adhesion tension.

The solid is compressed in this cell under a pressure of 2500 lb., and kept at this pressure by means of the bolted ends. Then one end of the displacement cell is connected through a pressure gauge with a compressed air container; the compressed solid att the other end of cell is wetted with a material giving zero contact angle with same, this liquid also extending out from the cell into an indicator capillary. When the cell is connected

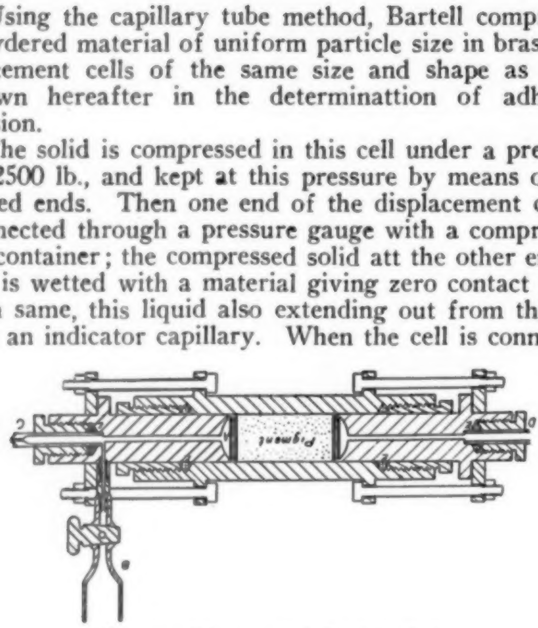


Fig. 7.—Diagram of Bartell Cell

up, the liquid is sucked in or is advanced into the solid through the fine capillary interstices. The opposing air pressure is built up by successive small increments until finally an equilibrium point is reached, when the liquid, as shown by the indicator gauge at the other end of cell, no longer advances, but remains stationary in the pores. This pressure can then be considered as that necessary to prevent movement of the liquid in the tube, and is identical with the pressure which would be exerted if the liquid had risen to its equilibrium heighth in a capillary tube of the same dimensions. It has been shown that water and benzene give no angle of contact with silica. Since the angle of contact is 0 deg., the formula given before simplifies as follows:

$$Cos\,\theta = 1 = \frac{rhdg}{2S} = \frac{rPg}{2S.}\text{ where } P \text{ is the equilibrium pressure equal to } hd.$$

From this equation it can be seen that the size of the interstices in any sand mixtures for paving work can be determined.

Transposing the equation,

$$2S = rPg, \text{ or, } r = \frac{2S}{Pg} \text{ where } g \text{ is the gravitational constant of dynes per sq. cm.}$$

Having determined the pore radius of a given material, by the above mentioned method, Bartell determines the angle of contact, which a contact angle liquid gives with a solid by means of displacement cells shown in Figs. 7 and 8. These cells are brass cylindrical tubes open at both ends, with closely fitting perforated plungers which can be inserted in these ends. The cell is of such size that the membrane or briquette contained in it, at the end of the packing process, is approximately three inches long by one inch in diameter. At the outer extremity of each of the plungers is sealed a glass capillary tube, one tube serving as a displacement indicator, the other, by means of a ground glass joint, furnishing a connection with a manometer or pressure gauge. The powdered solid of uniform size, thoroughly wetted by a liquid which shows an angle of contact with same, as for instance a-bromonapthalene with silica, is then packed in the manometer end of the cell by a suitable compression device under a pressure of 2500 lb., ends are then inserted and bolts then screwed down to keep the whole system during the test at 2500 lb. pressure. The cell is then connected up with air pressure as shown in Fig. 9 and the equilibrium pressure determined as before for the system. This equilibrium pressure is then inserted in equation (7) as before for the measurement of pore radius.

$$Cos\,\theta = \frac{rhdg}{2S} \quad \frac{Prg}{2S}$$

The surface tension of the a-bromonapthalene is known, r was determined in the previous experiment, P, which replaces hd, is the displacement pressure and g is 981; so $Cos\,\theta$ can be determined by inserting these values in the formula and calculating.

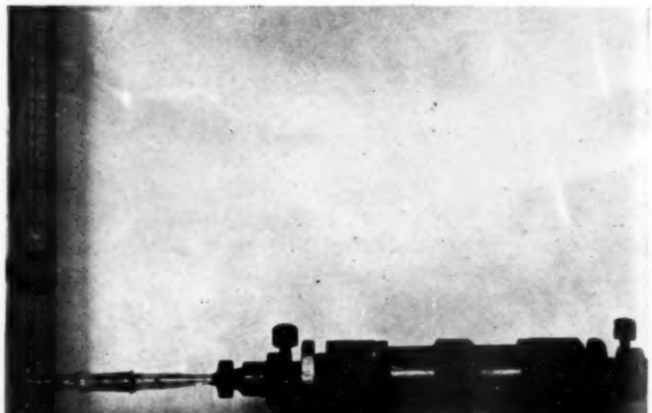


Fig. 8.—Displacement Cell

As shown before in equation (4) the adhesion tension for liquids showing an angle of contact with a given solid is

$$A_{12} = S_2\,Cos\,\theta_{12}$$

so substituting the value for $Cos\,\theta_{12}$ found in the experiment and the surface tension of the liquid, the adhesion tension of the contact angle liquid for the solid can be determined.

But suppose a liquid shows no angle of contact for the solid as is the case between petroleum and silica.

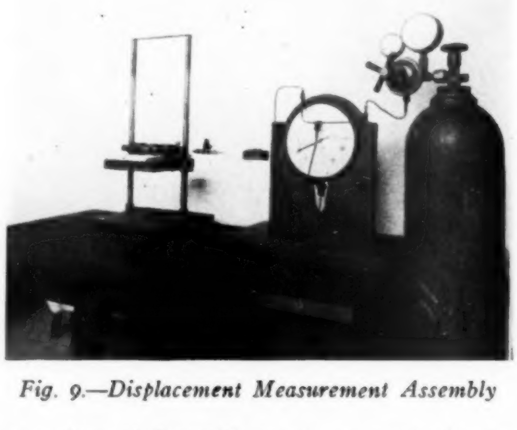


Fig. 9.—Displacement Measurement Assembly

Up to the time of Bartell's work no method was available to determine this value.

By a clever mathematical treatment, Bartell has shown that this can be determined from the following formula, equation (8),

$$A_{13} - A_{12} = Cos\,\theta_{23}\,S_{23}$$

or, $A_{13} = A_{12} + Cos\,\theta_{23}\,S_{23}$, where A_{13} is the adhesion tension between liquid denoted as *3*, showing no angle

of contact with solid *1*, A_{12} is the adhesion tension between the other liquid showing an angle of contact with same solid *1*, which has already been determined as above. $Cos\ \theta_{23}$ is the angle of contact, the interface between two liquids makes with solid *1*, and S_{23} is the interfacial tension between the two liquids.

It can be seen from an inspection of the formula, that this determination involves a measurement of the interfacial tension between the liquid showing an angle of contact with the solid and the liquid not showing any angle with the same solid. It also involves a measurement of the angle of contact which the liquid-liquid interface makes with the solid. Bartell determines the interfacial tension between the two liquids in a modification of the capillary tube method which will not be described here. The angle of contact which the interface between the two liquids makes with the solid is determined in the displacement cell previously shown.

The powdered solid, thoroughly wetted by the liquid showing an angle of contact, is packed in the manometer end of the displacement cell at a pressure of 2500 lb., as before until the cell is about 2/3 filled. Against this is then packed some of the solid material wetted by the liquid which shows no angle of contact, such as water. The plungers in the ends of the cell are secured in place as before to keep the pressure of the packed material constant at 2500 lb. The joint between the plunger and cylinder is then rendered leak-proof by screwing down a threaded nut and gasket.

After the displacement cell has been filled and assembled, the pressure end is connected to the manometer end of the cell and the equilibrium pressure measured as before. In a large number of determinations of liquid-liquid systems against carbon black and against silica, close agreements in duplicate experiments were almost invariably obtained. Organic liquids all displace water from carbon black, while with silica the direction of displacement is usually reversed.

Applying the same formula, No. 7, as before, $Cos\ \theta_{23}$ is determined from

$$Cos\ \theta_{23} = \frac{Prg}{2S_{23}}$$

Using the interfacial data found, and the displacement pressure necessary to hold the system in equilibrium, it can be seen that this angle can be determined.

Applying this value in equation 8, given above, and inserting the value for the liquid-liquid interfacial tension, and the adhesion tension of the contact angle liquid found before, it is seen that adhesion tension for a zero contact angle liquid for a solid can be determined, for

$$A_{13} = A_{12} + Cos\ \theta_{23}\ S_{23}$$

By going through the preceding typical procedure, it can be seen that the adhesion tension of water for silica can be determined. Since the adhesion tension of water for silica can be determined and is known, it becomes possible to determine the adhesion tension of different crude oils for silica. The calculations are carried out precisely as given. In the case of any new material such as asphalt, it will be necessary of course to determine ahead of time, if the water displaces the asphalt or the asphalt displaces the water, so that they can be put in a proper position in the displacement cell.

Tables I and II show the results obtained using different petroleum oils with silica sand. It can be seen from an inspection of the tables that sand likes water in every case better than petroleum. The adhesion tensions of the various petroleums for sand vary from 58.87 to 72.68 dynes per sq. cm., which is less than that of water (82.64 dynes per sq. cm.). Water will therefore have a displacing tendency for each of these different oils. It will also be seen that the cohesion of the oils, which is twice the surface tension of same, varies from 44 to 58.19 dynes per sq. cm., which is also less than the adhesion shown by these same oils. It can therefore be seen that petroleum spreads on silica with a zero angle of contact, for the adhesion constant mentioned in equation (6) is always greater than 1.

TABLE I.—PRESSURE OF DISPLACEMENT OF SOME CRUDE OILS BY WATER

(Silica, 350 mesh; pore size = 1.87×10^{-4})

System	Sp. Gr. Organic Liquid	Viscosity (ABS.) n X 10[illegible]	Surface Tension Crude Oils (S_2)	Displacement Pressure G./sq. cm.
Benzene-air silica	0.8725	....	....	308.6
Water-crude A	0.8837	290.0	28.58	180.7
Water-crude B	0.8210	36.4	24.77	208.8
Water-crude C	0.8738	264.0	27.00	208.2
Water-crude D	0.8347	55.0	24.69	196.2
Water-crude E	0.8262	53.9	25.03	259.3
Water-crude F	0.8337	49.3	25.70	213.3
Water-crude G	0.9196	672.7	29.09	108.6
Water-crude H	0.8056	20.7	23.70	115.5
Water-crude I	0.9388	87.5	28.82	227.3
Water-crude J	0.7909	24.9	24.01	215.0
Water-crude K	0.8850	349.9	28.90	183.2
Water-crude L	0.8300	36.2	28.46	189.0
Water-crude M	0.7879	31.3	22.00	255.5

TABLE II.—ADHESION TENSION VALUES FOR SOME CRUDE OILS AGAINST SILICA

(Silica membrane pore size = 1.87×10^{-4}; adhesion tension for water, $A_{13} = 82.64$)

System	Pressure Grams/sq. cm.	S_{23}	K_{23} ($\cos \theta_{23}$)	$K_{23} S_{23}$ or $A_{13}—A_{12}$	A_{12}
Bromo-naphthalene air	454.	44.59	0.9402	....	....
Water-bromo-naphthalene	444.	42.07	0.9676	40.31	41.93
Water-crude A ..	180.7	17.92	0.9659	16.57	66.07
Water-crude B ..	208.8	21.83	0.8770	19.19	63.50
Water-crude C ..	208.2	20.88	0.9164	19.09	63.55
Water-crude D ..	196.2	20.64	0.8716	17.99	64.65
Water-crude E ..	259.3	24.05	0.9882	23.77	58.87
Water-crude F ..	213.3	24.22	0.8075	19.56	63.08
Water-crude G ..	108.6	17.10	0.5823	9.96	72.68
Water-crude H ..	115.5	13 51	0.7841	10.59	72.05
Water-crude I ..	227.3	25.55	0.8157	20.84	61.80
Water-crude J ..	215.0	21.90	0.8995	19.71	62.93
Water-crude K ..	183.2	22.00	0.7634	16.80	65.84
Water-crude L ..	189.0	21.43	0.8088	17.33	65.31
Water-crude M ..	255.5	24.54	0.9536	23.41	59.23

Returning now, to a consideration of the different amounts of work done in applying a liquid to a solid, in adhesional wetting, spreading, wetting, and immersional wetting, it is remembered that the following equations govern:

Work of adhesion = $(S_1 - S_{12}) + S_2$ Equation (1).
Work of spreading = $(S_1 - S_{12}) - S_2$ Equation (2).
Work of immersion = $(S_1 - S_{12})$ Equation (3).

It can be seen that $(S_1 - S_{12})$ is common to all three equations, and this was shown in equation 5B, to be equal to the adhesion tension between solid and liquid, and to its work of immersion, therefore the above amounts of work can be determined by inserting the proper values for adhesion tensions in place of $S_1 - S_{12}$ in the above equations as follows:

Work of adhesion = $A_{12} + S_2$.
Work of spreading = $A_{12} - S_2$.
Work of immersion = A_{12}.

Using data shown in Tables I and II, the following additional values were calculated, as shown in Table III. As already mentioned, the petroleum oils spread with a zero angle of contact on silica, so the value of K will always be greater than unity.

TABLE III.—WORK VALUES IN DIFFERENT TYPES OF WETTING, USING CRUDE PETROLEUM OILS AND SILICA

Crude Oil Water	Surface tension Dyn sq. cm.	Work of Cohesion Dyn. sq. cm.	Adhesion Tension	K	Work of Adhes.	Work of Spread	Work of Imm.
A	28.58	57.16	66.07	2.31	94.65	37.49	66.07
B	24.77	49.54	63.50	2.56	88.27	38.73	63.50
C	27.00	54.00	63.55	2.35	90.55	36.55	63.55
D	24.69	49.38	64.65	2.62	89.34	39.96	64.65
E	25.03	50.06	58.87	2.35	83.90	33.84	58.87
F	25.70	51.40	63.08	2.45	88.78	37.38	63.08
G	29.09	58.18	72.68	2.50	101.77	43.59	72.68
H	23.70	47.40	72.05	3.04	95.75	48.35	72.05
I	28.82	57.64	61.80	2.14	90.62	32.98	61.80
J	24.01	48.02	62.93	2.62	86.94	38.92	62.93
K	28.90	57.80	65.84	2.28	94.74	36.94	65.84
L	28.46	56.92	65.31	2.29	93.77	36.85	65.31
M	22.00	44.00	59.23	2.69	81.23	37.23	59.23
Same values as above for a-bromonapthalene on silica, angle of contact 19.90 deg.							
	44.00	88.00	41.92	.953	85.92	–2.08	41.92
Same values as above for water on carbon, angle of contact 40.60 deg.							
	77.08	144.16	54.74	.759	126.82	–17.34	54.74
Same values as above for water on paraffin, angle of contact 107 deg.							
	72.08	144.16	–18.05		54.04	–90.13	–18.05

Generalizing on above results, it can be said that adhesional wetting work is positive when the angle of contact is less than 180 deg. There does not seem to be any case where this type of work is negative. Accordingly, it should follow that any liquid will wet any solid if the two are properly brought together in a manner that will result in adhesional wetting.

Immersional wetting is positive when the angle of contact is less than 90 deg., and is negative when the angle of contact is greater than this value.

Spreading wetting is positive only when the angle of contact is zero and is negative for all larger values of

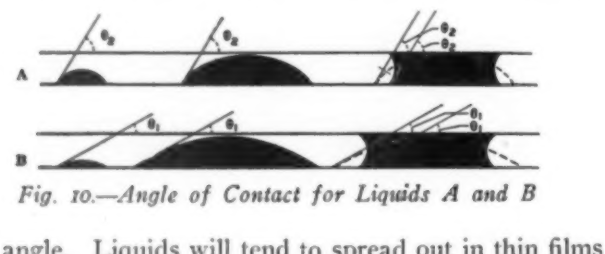


Fig. 10.—Angle of Contact for Liquids A and B

this angle. Liquids will tend to spread out in thin films over solid surfaces only when the contact angle is zero.

When the work is shown as negative, it means that outside work must be applied to make the liquid spread. The liquid which will spread the most readily in any of the given types, is the one which shows the highest positive values.

As asphalt wetting is mostly a spreading wetting phenomenon, the system showing highest work by the system itself will wet the readiest.

In Fig. 10, Prof. Bartell illustrates how the angle of contact of a liquid with a solid may influence the size of voids between the drops on a glass plate. In the upper part of this figure, is shown a liquid having a greater angle of contact than the lower one. It can be seen that the voids are increased on account of a large angle of contact. Supposing the liquid spreads with a zero angle of contact, then it should be possible to bring the two glass plates down to each other without any voids in between.

Fig. 11 shows how the angle of contact may influence the shape of holes when a liquid is in contact, with materials giving different angles of contact with a liquid. The upper left hand part of the bubble shows the lowest angle of contact, followed by the part in the upper right hand and lower parts in the order of their increasing angle of contact.

Fig. 12, which is self-explanatory, shows that with perfect adhesion the amount of oil held between the particles of a pigment immersed in a vehicle is decreased to a minimum.

Fig. 13 shows the result of some work done by the Chicago Testing Laboratory, which they kindly allowed me to use.

Each point shown on the curves represents a mixture, in which the asphalt is so proportioned, that theoretically all the voids should be filled. Still on making briquettes of the mixture containing the min-

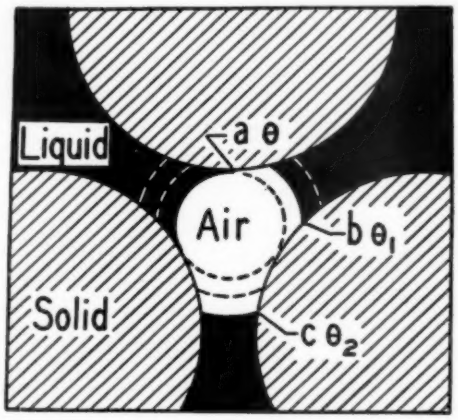


Fig. 11.—Volume of Air Entrapped Is Dependent Upon Contact Angle

eral matter and the calculated amount of asphalt required to fill the voids, they show voidages as illustrated in the curves. A paving mixture containing ordinary limestone dust, to which the asphalt does not adhere

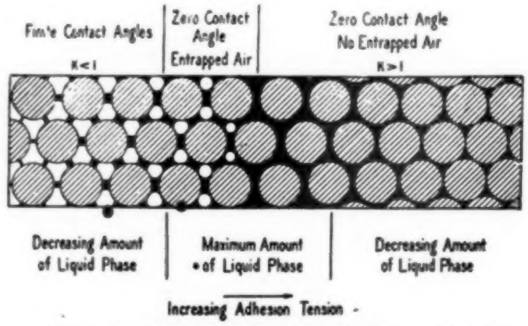


Fig. 12.—Amount of Liquid Absorbed Is Dependent Upon Adhesion Tension and Contact Angle

very well, shows a higher percentage of voids than does a similar mixture containing a filler material of pulverized limestone rock asphalt, to which the asphalt adheres perfectly. By increasing the adhesion of its components, the compressibility of the mixture is improved.

Prof. Bartell has not done any work on obtaining

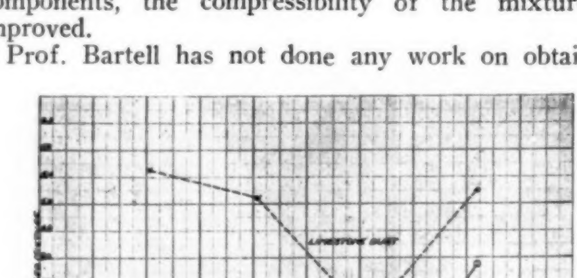


Fig. 13.—Compressibility

the adhesion tension between asphalts and sands. Unless run at elevated temperatures to decrease its viscosity, the asphalt is too viscous to flow into the capillaries in the mineral membrane. The most viscous oil he has worked with is one possessing an absolute viscosity of 673.

Prof. Bartell, however, has run adhesion tensions of mixtures of liquids possessing a high degree of adhesion to a material like silica, with diluents for same, which show lower adhesion tensions for the solid. Thus the results of adhesion tensions of a mixture of aniline and

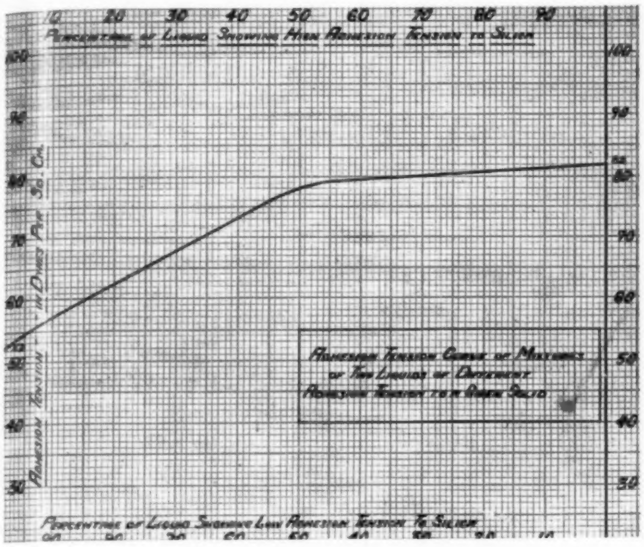


Fig. 14.—Adhesion Tension Curve

benzol in different proportions, have been drawn in curve form by me from a description given to me by Prof. Bartell. This is shown in Fig. 14. It can be seen from an examination of the curve, that it flattens out at 50 per cent concentration and that adhesion tension obtained at this concentration, seems to bear a certain fixed relation to that obtained at 100 per cent concentration.

The reason for my going into the work of Bartell is to illustrate some of the fundamental principles underlying wetting phenomena. While this may seem to be rather lengthy and exhaustive, it is by no means complete, so students in this subject are referred to articles Prof. Bartell has published in the Journals of the American Chemical Society, *The Journal of Physical Chemistry*, and the *Annual American Colloid Symposium Monographs*.

Fig. 15 shows a new device by Geo. Barsky and S. A. Falconer, chemists for the American Cyanamide Co., used in the study of flotation agents. It is, as can be seen, a modification of Bartell's Adhesion Test Cell, and while capable of quantitative results, should serve as a quick indicator of relative adhesion of liquids to solids.

Mr. A. R. Ebberts in a paper on the emulsifying action of fillers used in sheet asphalt construction, using an oil-sample-bottle test, shows the tendency of some fillers to form asphalt-in-water emulsions and others to form water-in-oil emulsions. Using the method devised by me as described in the next installment of this paper, I have found that fillers shown in Class 1 like water better than asphalt, whereas those in Class 2 like asphalt better than water.

CLASS 1	CLASS 2
Silica (impure)	Pure limestone dust or marble
Iron oxide	Hydrated lime
Aluminum oxide (Bauxite)	Limestone rock asphalt powder
Calcium sulphate (Gypsum)	Calcined coal mine waste such as haydite
Barytes	
Lithophone	
Impure limestone	
Light calcined magnesia	
Certain kinds of slag	
Infusorial earth	

While Bartell's method is the most accurate and most readily duplicated of all those proposed, it is open to the criticism that the test must be run either at a hot temperature, or else in connection with the solvent to make it applicable to asphalt. It is also a rather lengthy test to make. For the purpose of

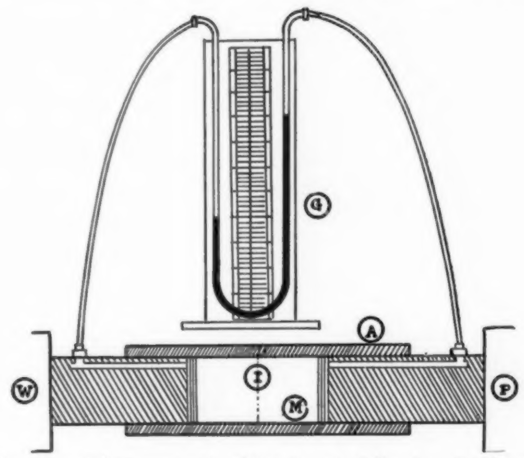


Fig. 15.—Diagrammatic Sketch of Adhesion Indicator

testing the adhesion of asphalt to a new and unknown mineral matter, it can be seen that the steps involved are: the preparation of mineral as to proper grading, determination of pore radius, determination of adhesion tension of displacing liquid to aggregate, and the test for adhesion of asphalt to aggregate, all of which are rather time consuming. However, for the purpose of comparing adhesion of various asphalts to a single mineral, such as silica, it can be seen that this time can be shortened to a very large extent. Contrary to the original idea that the mineral matter used had to be 300 mesh or finer in size, this method can be run on material as coarse as 40 mesh.

Gas Tax Diversion

It can be said that the diversion of gasoline tax money is insignificant at present, but political forces are gathering here and there with the intent of conducting raids on heretofore untouched funds. Unless defensive steps are taken the future may see extensive inroads made on gasoline tax money. During 1930 approximately $15,500,000 in gasoline tax money was diverted to purposes that had no relation whatsoever with roads or with motorists as a group.

The strangest use of gasoline tax money occurs in an eastern state. Last year that state paid out $75,000 of gasoline tax money to the State Department of Conservation for oyster propagation. More than one-fourth of the gasoline money collected by a southern state in 1930, $3,780,000, was diverted to the erection of school buildings and the support of schools. In another state in the South $2,200,000 of gasoline tax money went for the same purpose. In another state $7,000,000 is diverted annually for school purposes.

LETTERS TO THE EDITOR

Is Speed Costly

In a letter to the editor Mr. H. J. Fixmer, Municipal Engineer, President of the Illinois Society of Engineers, by way of diversion submitted the following satirical analysis. He cleverly reveals the fallacious data sent out by a motor club

Editor, ROADS AND STREETS:

Dear Sir:

The March issue of ROADS AND STREETS is a very interesting collection of "data." While one should not believe "everything" he reads—he ought to be rather confident of the statements appearing in his favorite engineering journal.

On page 124 the following items appear:

"Total highway mileage—approximately 3,100,000.

"Total surface and improved—approximately 663,000.

"Per cent of total improved—approximately 20 per cent."

On page 138 appears a statement based on investigation of the Chicago Motor Club to the effect, "that a mile a minute clip is from three to four times more expensive than when your speedometer says 40 or 45," etc.

Some years ago I ran across a table purporting to show the cost of "speed" and "cost saving of improved roads. The statement credited to the investigators of the Chicago Motor Club seems to make the figures in this table appear too conservative, whereas I thought them of dubious value! Below is a copy of the table, the source of which I have no record, or recollection:

Cost in cents per mile for average motor

Dirt Road	Gravel and Macadam Road	Hard Road	Speed in Miles per hour
6	....	5	10
8	5	4	15
10	6	4½	20
15	7	6	30
....	10	8	40
....	15	12	50+

On page 142 is the editorial, "Mr. Congressman—Think!" appears the following data:

Number of registered automobiles, 26,500,000.

Cost of operating average car, approximately 6c per mile.

Cost of operating average truck, approximately 15c per mile.

Total annual cost of vehicle operation, $20,000,000,-000.

A DOLLAR SAVED IS A DOLLAR EARNED

If we assume that 75 per cent of the existing vehicles use the present improved system (663,000 miles) exclusively, and that the remaining 25 per cent use the present system but 50 per cent of the time, then we have the equivalent of 12½ per cent dependent on the unimproved (80 per cent) road system.

Now 12½ per ceent of $20,000,000,000 equals $2,500,000,000, or cost annually to vehicles required to use the unimproved system. If, by paving these roads, we could save 50 per cent of this expense, then $1,250,-000,000 (on the pay as you go method) could be wisely spent annually on the 2,400,000 mile unimproved road system, or approximately $500 per mile. This is an average. Some roads might warrant an expenditure of $20,000 per mile and some nothing at all.

But, according to the table above, which is apparently confirmed by the Chicago Motor Club investigators, improving the roads, by reason of the unreasonableness (?) of the drivers to increase speed, *increases the cost of operation* of a vehicle over the cost of operating at more modest speed (or pace) on the unimproved road! Analyzing the situation, assuming the table above is based on facts, which by the way is more conservative than the claim of the Chicago Motor Club, we get this result:

Suppose a trip 60 miles long is made. (Charge drivers time at 60c per hr.)

Hard Road at 60 miles per hr. @ 12c = $7.20 plus 60c (driver) = $7.80.

Dirt Road at 15 miles per hr. @ 8c = $4.80 plus $2.40 (driver) = $7.20*.

Hard Road at 30 miles per hr. @ 6c = $3.60 plus $1.20 (driver) = $4.80.

*This speed gives 4 hrs. employment! (Not to be overlooked these days.)

Thus, it appears, it is not economic to spend money on roads to achieve a speed in excess of 30 miles per hour! Further if the motorist insists on a 60 mile speed then all the money spent improving roads is wasted; for the above summary shows, it is cheaper to travel on a dirt road at 15 miles per hr. than on a hard road at 60 miles per hour!

If the Chicago Motor Club is wrong, as well as the "table," we ought to know it. Perhaps the auto makers will enlighten us. Finally, this thought remains. Maybe the cause of our depression is too much SPEED? This, I cheerfully refer to that notable economist-engineer, Mr. H. P. Gillette for an answer—How far and how fast can we humans go?

Yours truly,

H. J. Fixmer.

"Roads Must Be Kept Open"

To the Editor: In an article appearing on page 516 of the December, 1931, issue of ROADS AND STREETS, entitled "Roads Must Be Kept Open," the opening statement reads, "It so happens that the General's Highway to Giant Forest, Sequoia National Park is the one place in California where it is possible to keep open a road the year round to the California big trees or Sequoia Gigantea."

This statement is not correct, for a state highway has been kept open the year round for the past three years into the Calaveras Big Tree Grove. This is a splendid grove of Sequoia Gigantea; in fact, it is the first grove discovered by white men in the state and is now included in a State Park.

R. E. Pierce,
District Engineer, Division of Highways, California Department of Public Works, Sacramento, Calif.

EDITORIALS

Do Some Sciences Need De-lousing?

INVENTIONS, as to difficulty of accomplishment, may usually be thrown into one of two classes: (1) Those in which the original possibility was not easily seen; and (2) those in which the pracitcal execution of an easily seen possibility was very difficult. The Edison phonograph exemplifies the first class. The Mergenthaler linotype exemplifies the second class. Almost any skilled mechanical engineer could have made a phonograph had Edison's idea of its possibility been presented to him. On the other hand many a skilled inventor struggled unsuccessfully to make a practical typesetting machine.

What is true in this respect as to mechanical inventions is also true as to the discovery of Nature's secrets. In many instances the greatest difficulty in finding the cause of a phenomenon lies in hitting upon the first clue. Clues invariably come from seeing some likeness between the puzzling phenomenon and some better known phenomenon. Such was the clue by which Huygens was led to explain light as a wave analogous to a sound wave. Similarly, Fitzgerald was led to explain the constant velocity of light by assuming a shortening of the measuring "rod" as a result of its velocity. In the latter case Lorentz siezed the Fitzgerald clue, applied the mathematical theory of the electron to it and deduced the now accepted formula for change of length with change of velocity.

There are not a few editors of technical periodicals and society proceedings who have failed to realize that even embryonic theories, or hypotheses, are often exceedingly valuable. Failing to appreciate such values, they refuse to publish unestablished theories, and they are particularly prone to make such refusals when the unestablished theory conflicts with one that is regarded as being established.

When is a theory established? Certainly not when it agrees only with the facts that it was invented to agree with. Science is literally lousy with that sort of theory, and the de-lousing that inventors attempt to apply is often delayed many years by the refusal of editors to print their "stuff."

A scientific iconoclast is among the best hated of mortals; often the hate has real reason behind it; for to be iconoclastic one must have a very good opinion of one's own opinions. This of course, rides with the unpardonable sins. Descartes was such an iconoclast, and if you think he wasn't hated read Maclarren's criticisms in "An Account of Sir Isaac Newton's Philophical Discoveries" (1750).

Doubtless many editors have but a crude idea of how scientific discoveries are made and an even cruder idea of how the truth of a theory can be established. Truth is not established by quoting authorities, nor by long existence of a general belief. To be true a theory must fit facts that it was not designed to fit, and it must fit them so neatly that probability calculations will show substantial odds against the fits being accidental. How many scientific theories will stand this test? Relatively few, if our personal acquaintance with science has given us a fairly typical cross-section of this realm of knowledge.

Most writers of scientific books write with such dogmatic assurance that the reader finds it difficult to winnow the wheat-theories from the chaff-theories. Indeed it may not occur to the reader that there is any chaff at all in a scientific book that really consists of little else. But let him try to apply the mathematical probability test above given, and he will soon find that it serves to reject as unproven many a theory that has long been taught and stoutly championed.

The fewer the quantative laws the more numerous are the unestablished theories in any science. Judged by this criterion the following sciences must contain a very large number of unreliable theories: Political economics, biology, medicine, meteorology and geology. Quantification permits and indeed necessitates testing either a law or a theory by the degree of its correspondence with facts. This in turn facilitates the application of the principles of mathematical probability to ascertain whether the correlation is accidental or not.

H. P. Gillette

Fundamental Highway Concepts

STUDIES of the improvement of a highway are made, not only from the political expediency point of view, but occasionally from the economic point of view. When the latter type of analysis is employed there are two fundamental concepts that underlie its employment. In studying a proposed highway improvement as an economic problem we naturally endeavor to decide upon a type of construction which when considered in coördination with a traffic survey will give satisfactory highway service at the lowest unit cost. Two fundamental assumptions that are made in connection with an economic study of highway transport or highway improvement are:

1. Interest can be earned on public funds, and
2. Savings to operating expenses of motor vehicles because of highway improvement is considered as income to the vehicle operator.

It is commonly accepted practice to consider that annual interest on the first cost of constructing a highway is a charge against the annual cost of the highway. This point seems to me to be open to dispute. Public funds are never invested in revenue producing enterprises. Disregarding the questionable suggestion that public officials could invest public money in interest bearing securities, it is common knowledge that collected taxes and other public funds are apportioned back to smaller political subdivisions immediately. Before the construction season is over these funds are usually entirely expended. Some state laws require that depositories pay interest on daily balances of public funds. If 2 per cent is paid on 90 per cent of the daily balance, a good interest is being paid. As stated before, the funds are usually entirely expended at the end of a construction season which means that the average amount on which interest is paid is only 90 per cent of 50 per cent of the total fund.

Savings to operating expenditures is an income. To save a certain amount we are justified in making a capital investment that will cause that saving over the economic life of the property created. Hence in capitalizing the saving we should not make the mistake of capitalizing for an indefinite period but should do so only for the economic life of the property. Tests and

experimental work done under the direction of Prof. T. R. Agg, at the Iowa Engineering Experiment Station indicate that vehicle operating costs on low cost treated road surfaces are 20 per cent greater than on high type paved surfaces and that earth, loose gravel and untreated surfaces cause vehicle operating costs to mount approximately 50 per cent over the cost of operation on high type surfaces.

Improving highways can thus be seen to be desirable. This is brought forcibly to our attention when we calculate the total dollars and cents saving possible to all motor vehicle operators by improvement.

Engineering and Experiment

ENGINEERING has been aply defined as the systematic application of science to problems of economic production and service. The engineer's ultimate aim, therefore, is to affect a desired result at a minimum cost for maximum profit. The engineer who does not know actual costs does not know good engineering. Recently the writer talked with a man who holds a responsible engineering position. The discussion trended into construction work, design, specifications, trade names, and contract work. During the conversation the writer was told that several pieces of road surfacing were going to be purchased in place and used as experiments to determine which would be the more suitable under the conditions. It was admitted that conditions at this particular place were exactly similar to those existing close by where another man, an engineer, bought contract work by specification.

What was wrong here? Why did the man buy cats in a bag in order to find out which one would stay? The answer is simple, though two-fold.

First, this buyer did not know costs of this construction work in which he purported to be specialized. Second, he was not acquainted with methods of manufacture or specifications of materials to be employed in the contract. This man would have been shocked and offended if he had been told that he was not a good engineer.

Bridge engineers are carefully trained in the analyses of strains and stresses of materials in order that they may design the most economic section to carry the load. This is a cost analysis of a project in part. At this point they cease to be engineers, usually. Their education and training usually has ceased at the production of the design. The fabrication is not a bridge until it is in place ready to carry traffic. On substructures their ignorance of analyzed costs is apt to be profound, and particularly as it relates to cofferdams, caissons, etc. All this they are supposed to pick up through contact with the work.

Evidently the man with whom the writer had the conference mentioned above had failed to absorb or learn the important cost data in the special field in which he is working.

The very act of gathering cost leads an engineer to think along proper lines. He ceases to reason by intuition and ceases to experiment for himself with other people's money. He comes to appreciate, also, the contractor's point of view. He begins to dig test pits and make borings. He begins to study materials and specifications. He begins to read technical periodicals and society proceedings. He, in short, begins to study the economics of specified works from the raw product to the erected works. In so doing he is engineering the project or scheme at the minimum cost for maximum profit. He ceases to buy constructed projects with which to experiment. In a country the size of ours many agencies have recorded the results of experiments. The engineer worthy of the title knows where to obtain this information to assist him in his choice of an economic fabrication or project.

It is not the intention of the writer to discourage research but to have it handled by recognized organizations. By so doing the results of the experiment will be available to the profession at large. Those interested in using the data may then design and construct for minimum cost and maximum profit.

Reducing City Taxes

WHAT the public is interested in is not how much taxes they are paying so much as how they are being spent. Wasted expenditures grate upon the patience of the city taxpayer. Graft, incompetence, inefficiency and political favoritism are not cherished by them in the least.

By reorganizing many city departments and consolidating bureaus and commissions city expenditures would automatically reduce yet needed public improvements would continue.

It is possible to reduce taxes without reducing or eliminating needed public improvements. If an epidemic should occur where a proposed sewage disposal plant was eliminated from the budget, the elimination would certainly not be saving the taxpayers anything. If, even, the needed expenditures for correctly operating the sewage plant were curtailed below a point necessary for efficient operation the reduction would evidently be parsimony, not saving. This is only one of many cases that might be cited.

Following is a list of possible means of tax reduction:

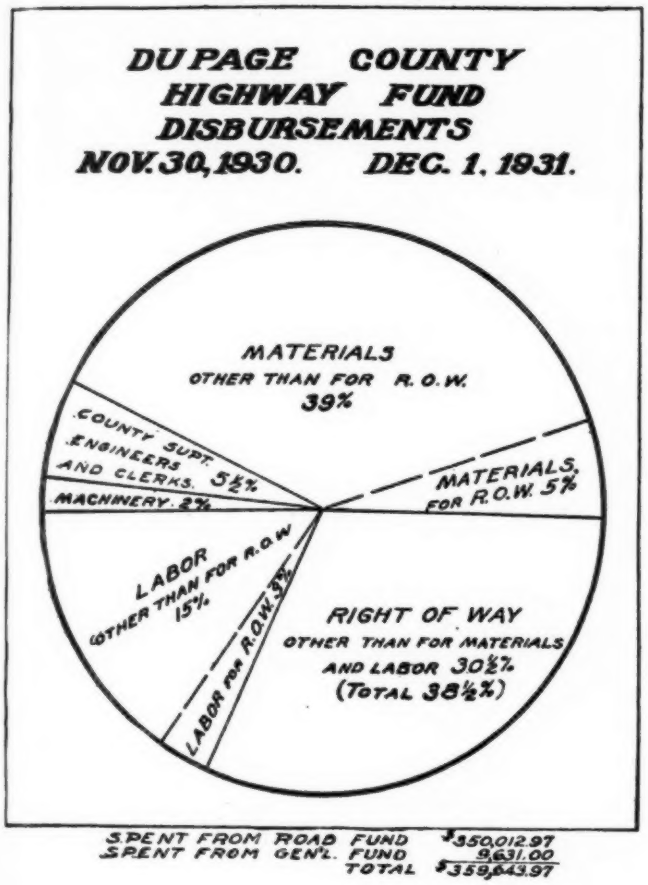
1. Reduce educational frills.
2. Postpone projects tending toward luxuries rather than necessities.
3. Postpone land purchases for schools, park, etc., unless to be used immediately.
4. Draw the line between nonproductive expenditures and those which bring direct savings to the citizens, in either cash savings or increased public health and safety; such as sewer and water extensions, and street paving.
5. Use unemployment funds to a greater degree for construction of real benefit to the city rather than hand out as charity.
6. Too great a decrease below the normal of city expenditures is definitely harmful to attempts now being made to business and industry.

In most cities and towns, councils and boards of aldermen have no jurisdiction over school expenditures. Yet this item accounts for half and over of the demands on the taxpayer. This question bears investigation.

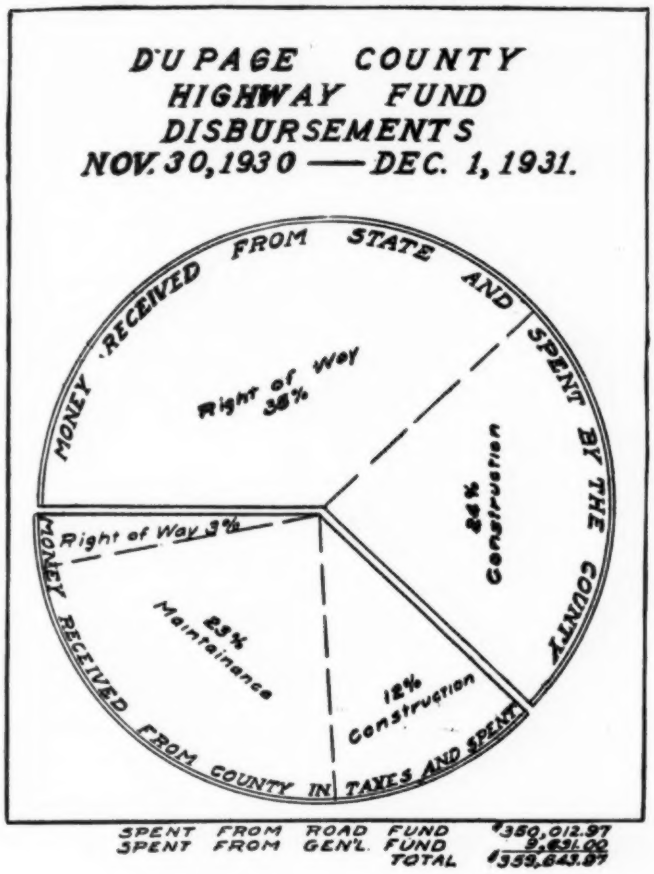
V. J. Brown.

County and Township Roads

GRAPH NO. 1.



GRAPH NO. 2



COUNTY *Shows How* HIGHWAY MONEY *Is Spent*

PUBLICITY of this nature—and even more detailed and specific—should appear regularly in all newspapers of the county to keep the citizens and voters posted as to the functions, accomplishments, and value of the county highway departments. Charts, curves, pictures, and tables showing receipts and disbursements of highway funds and comparing these with other county, city, state and federal departmental expenditures are data, the presentation of which a highway department owes to the taxpayers.—Editor.

THE accompanying graphs show the total amount of money spent for road purposes from November 30, 1930 to November 30, 1931, inclusive, and the percentage used for the different kinds of work and materials. The graphs cannot show the exact picture for the reason that they simply cover the amount spent for the period specified, while the engineers and some labor and material were used on work completed

during this period, but which will not be paid for until 1932. They also include work done for townships for which no pay will be received. Some work however, was carried over from the previous year, but it would not amount to the work carried over into 1932. The county highway superintendent and clerks were paid from the general county fund, but as this was for road purposes it has been added to the road expense so as to make the money spent for road purposes as nearly correct as it could be made.

The item shown as "Materials" covers the materials delivered on the job, and this of course means that a part of this was spent for labor, probably about one-third.

The graph however does give a very good picture and can be verified by figures to the nearest one-half of one per cent.

Graph No. 1.—In this graph thirty-nine per cent shows for materials used, other than for right-of-way, which means that thirty-nine per cent of the total of $359,644.00, or $140,261.00, was the amount used for materials such as gravel, stone, etc.

The item of five per cent for Materials was for fencing on right-of-way.

The item of two per cent for Machinery, covers new machinery, repairs, gas and oil.

The item of five and one-half per cent for engineers, covers the salary of the county superintendent of highways, clerk, and all engineers and assistants for work done for the state and county, and for assistance given to the townships.

Graph No. 2.—This graph shows the total amount of all monies spent. The items of thirty-eight per cent spent for right-of-way and twenty-four per cent spent for construction, or a total of sixty-two per cent of the total amount spent, was received from the state in gas tax and refunds. The balance of the money spent was received from the taxes for road purposes in DuPage county. Taking the two sources of revenue, it seems we have spent of the total amount, forty-one per cent for right-of-way, thirty-six per cent for construction, and twenty-three per cent for maintenance.

We did not include in the total amount spent the small sum of money given to the townships as assistance in constructing bridges, amounting to about $12,000.00, as this assistance to the townships must come, according to law, from the general county fund and not from the road fund.

It is readily seen that a good deal of money goes for right-of-way purposes at the present time, but as the state is putting a concrete pavement on this right-of-way, it is to the county's advantage to spend this money in order to secure the roads.

In my opinion, after the state has constructed the state bond issue roads and we have finished securing this right-of-way, the county road tax could be materially decreased and the gas tax, which is mainly used for right-of-way now, could then be used for construction and maintenance purposes.

There are only a few more miles of the county bond issue system left to be completed, and on this system, which the county voted to be built of macadam, a good deal has been completed with concrete; and as the county still has a considerable amount of money due from the state as refunds on these roads, and which they are just beginning to receive, it will be possible to use this money as it becomes available to complete the main roads that are not completed and our road tax, in my estimation can be reduced.

Taken as a whole DuPage county now has a good system of highways and with the number of roads that can be completed with the money available, this system will continually get better.

With the increased traffic and the heavy truck traffic the problems of maintenance is becoming harder all the time, and a good deal of attention will have to be paid to this problem in the future.

All matters pertaining to road purposes are handled by the Board of Supervisors, who in turn are represented by a committee of five members of the Board and myself, and the office is maintained for the convenience of the citizens of the county. Any citizen is welcome to get first hand information from this office. If there is any criticism to be made or information wanted, the best place to get action and information is at the headquarters of the highway department, for it has been my experience that when matters are thoroughly understood by all parties, mistakes can be rectified and problems settled without difficulty.

Acknowledgment.—From the West Chicago Press, weekly newspaper in Du Page County, West Chicago, Ill.

Abolish Township Roads?

Minnesota may well observe with interest the operation of Iowa's new law which does away with township roads, puts all (except trunk) highways under control of the boards of county commissioners.

A friend leaves a note on the desk: "In Iowa all roads are plowed open. I had to go to Pilot Grove on the state line, so I went through Iowa, came to the state line from the south. Why not save in Minnesota by taking all roads out of local control, put them into the hands of the county, provide all the year 'round travel?"

Another chap noticed this and left another slip with this written thereon: "Some roads in Emmett county haven't been open all winter and a man working on a snow plow said last Sunday it would be two weeks before they are cleared if it doesn't snow any more. Two men and a 10-ton 'cat' have been working day and night at the drifts ever since the first storm a month ago."

There you have evidence on both sides, but we incline to the county control idea. Obviously townships are too small units to provide, maintain and operate adequate construction, maintenance and snow removal equipment. Given time to get into operation, the county unit system is certain to prove the more effective and least expensive—*Fairmount Sentinel, Minnesota Highway News.*

A Curiosity of Figures

It may be hard to believe but it is true that

$$
\begin{aligned}
1 \times 9 + 2 &= 11\\
12 \times 9 + 3 &= 111\\
123 \times 9 + 4 &= 1111\\
1234 \times 9 + 5 &= 11111\\
12345 \times 9 + 6 &= 111111\\
123456 \times 9 + 7 &= 1111111\\
1234567 \times 9 + 8 &= 11111111\\
12345678 \times 9 + 9 &= 111111111\\
123456789 \times 9 + 10 &= 1111111111
\end{aligned}
$$

—*Detroit Purchasor.*

Leaders are readers.

Pinkham Notch, White Mountain National Forest, New Hampshire

National Forest

Low Cost

Roads and Trails

Evans Notch Road, White Mountain National Forest, Maine

IT is well, while considering federal aid appropriations for highway work by which the states are recipients of this widely distributed unemployment relief activity, to consider the not insignificant proposed appropriations for roads and trails in forests, Indian reservations, and other federal property. The following table shows allocation of the funds as proposed in HR. 9642, now pending in the senate:

TABLE I—EMERGENCY MEASURE PROPOSAL

A. Federal aid highway system	$120,000,000
B. Construction and improvement of national-forest highways	5,000,000
C. Construction and maintenance of roads, trails, bridges, fire lanes, etc., in national forests	5,000,000
D. Construction, reconstruction, and improvement of roads and trails, inclusive of necessary bridges, the national parks and national monuments under the jurisdiction of the Department of the Interior	3,000,000
E. Construction and improvement of Indian reservation roads	1,000,000
F. Survey, construction, reconstruction, and maintenance of main roads through unappropriated or unreserved public lands, nontaxable Indian lands, or other Federal reservations other than the forest reservations	2,000,000
Total	$136,000,000

Following is an abstract from the last annual report of the Forester and indicates the scope of activities embraced in national forest road work:

Table II shows the mileage and the estimated expenditure required to complete the planned system of transportation for the national forests. It includes forest highways, forest-development roads, and trails. Forest highways are of primary importance to States, counties, and local communities; development roads are of primary value for the protection, administration, development, and use of the forests; and trails are of primary use for protection. More intensive study of the transportation needs of the properties has added a considerable mileage of new development roads and trails not included in the system as reported last year.

Tables III and IV furnish information regarding forest-road appropriations and accomplishments. A

TABLE II — CLASSIFICATION OF MILEAGE IN FOREST ROAD AND TRAIL SYSTEM

Class	Total Miles	Satisfactory standard Miles	Unsatisfactory standard Miles	Nonexisting Miles	Expenditures required to complete Dollars
Forest highways	16,532	6,122	9,048	1,362	$189,100,890
Forest-development roads	65,861	22,724	16,638	26,499	65,056,590
Trails	155,597	112,427	9,047	34,123	5,497,990
Total	237,990	141,273	34,733	61,984	259,655,470

TABLE III—CONSTRUCTION, IMPROVEMENT, AND MAINTENANCE OF ROADS AND TRAILS FROM FOREST ROAD APPROPRIATIONS AND OTHER FEDERAL AND COOPERATIVE FUNDS, BY STATES, JUNE 30, 1931

State	Fiscal year 1931 Constructed Roads Miles	Fiscal year 1931 Constructed Trails Miles	Fiscal year 1931 Maintained Roads Miles	Fiscal year 1931 Maintained Trails Miles	Total to June 30, 1931 Constructed Roads Miles	Total to June 30, 1931 Constructed Trails Miles
Ala.	12.6	....	114.9	....	63.1	....
Alaska	10.0	41.2	230.2	162.0	237.1	439.7
Ariz.	327.6	110.5	1,952.7	2,860.0	1,808.6	1,748.5
Ark.	171.9	127.5	257.2	518.6	648.4	646.4
Calif.	762.4	401.2	9,610.5	18,007.7	3,297.7	3,947.8
Colo.	79.3	422.4	772.4	11,420.8	1,480.9	5,067.3
Fla.	575.8	....	66.0	....	824.7	....
Ga.	48.3	40.0	157.0	197.2	112.3	252.6
Idaho	310.9	2,216.4	2,660.6	19,581.0	2,352.9	14,383.5
Ill.	....	....	....	....	....	....
Kans.	....	....	....	....	3.4	....
Ky.	....	....	....	....	....	....
La.	77.5	....	....	....	77.5	....
Me.	....	15.2	5.3	45.8	5.3	61.0
Md.	....	....	....	....	....	....
Mich.	176.5	....	244.0	....	260.5	....
Minn.	27.3	40.0	284.8	369.6	390.3	536.7
Mont.	146.4	2,333.8	1,575.3	14,935.2	1,139.2	9,157.0
Nebr.	....	....	48.8	....	48.3	....
Nev.	25.8	42.5	320.5	1,514.0	479.9	896.1
N. H.	9.7	39.0	43.0	446.0	57.9	485.0
N. J.	....	....	....	....	....	....
N. Mex.	189.2	66.0	1,595.0	3,109.0	1,040.5	1,558.1
N. Y.	....	....	....	....	....	....
N. C.	30.5	27.6	213.2	595.3	200.7	640.6
N. Dak.	....	....	....	....	1.0	....
Okla.	3.0	....	19.1	....	27.7	16.5
Oreg.	633.8	895.5	6,176.7	14,161.8	3,659.4	7,388.0
Pa.	12.0	23.0	124.5	....	59.2	23.0
Porto R.	2.0	....	....	36.6	6.6	36.3
S. C.	....	....	12.0	10.0	6.3	18.2
S. Dak.	20.5	5.9	138.0	41.6	307.8	77.6
Tenn.	12.2	45.5	83.8	577.9	105.3	620.4
Utah	118.9	169.3	1,063.9	3,095.8	1,185.2	3,617.6
Va.	24.6	78.6	74.1	443.2	135.5	871.8
Wash.	274.0	1,198.4	2,006.3	11,871.0	1,287.1	6,628.5
W. Va.	39.0	100.0	118.8	339.9	117.0	443.7
Wis.	65.4	....	....	....	65.4	....
Wyo.	51.2	172.2	757.2	4,860.0	1,025.6	2,375.0
Total	4,238.3	8,611.7	30,725.8	109,199.7	22,518.3	61,936.9

TABLE IV—DISTRIBUTION AMONG THE STATES OF THE APPORTIONMENTS FOR THE FISCAL YEAR 1932

State	10 per cent fund	Forest highways	Forest-road development	Total
Ala.	$ 54.55	$ 7,990.00	$ 13,484.00	$ 21,528.55
Alaska	5,172.55	945,548.00	18,123.00	968,843.55
Arizona ..	27,567.83	593,906.00	155,482.00	776,955.83
Ark.	8,014.28	92,244.00	75,689.00	175,947.28
Calif.	112,329.78	1,432,765.00	517,317.00	2,062,411.78
Col.	54,084.80	678,687.00	195,213.00	927,984.80
Florida ..	4,023.90	32,769.00	18,143.00	54,935.90
Georgia ..	868.09	19,385.00	27,827.00	48,080.09
Idaho	53,232.45	1,045,437.00	483,866.00	1,582,535.45
Illinois	....	826.00	....	826.00
La.	.65	764.00	5,268.00	6,032.65
Maine	321.44	2,889.00	2,223.00	5,433.44
Mich.	393.06	17,680.00	30,994.00	49,067.06
Minn.	3,553.45	64,333.00	21,320.00	89,206.45
Mont.	26,860.79	819,893.00	281,255.00	1,128,008.79
Neb.	842.45	9,821.00	1,624.00	12,287.45
Nevada ..	10,372.28	187,008.00	17,764.00	215,144.28
N. H.	4,631.38	45,608.00	18,459.00	68,698.38
N. Mex. ..	12,884.58	415,539.00	101,940.00	530,363.58
N. C.	1,901.57	28,060.00	35,609.00	65,570.57
Okla.	605.91	3,628.00	8,365.00	12,598.91
Oregon ..	49,023.00	1,344,741.00	405,314.00	1,799,078.00
Pa.	1,333.75	18,553.00	30,448.00	50,334.75
Porto R.	25.50	1,127.00	2,071.00	3,223.50
S. C.	254.39	3,376.00	1,834.00	5,464.39
S. D.	12,839.69	79,984.00	17,591.00	110,414.69
Tenn.	1,206.14	25,724.00	22,447.00	49,377.14
Utah	23,221.89	338,185.00	66,039.00	427,445.89
Va.	2,341.50	32,371.00	34,663.00	69,375.50
Wash.	46,069.60	739,295.00	241,761.00	1,027,125 60
W. Va. ..	189.53	15,739.00	28,222.00	44,150.53
Wis.	.63	6,281.00	15,546.00	21,827.63
Wyo.	32,022.18	449,844.00	104,099.00	585,965.18
Undis.	....	....	[1]1,229,200.00	1,229,200.00
Total ..	$496,243.59	$9,500,000.00	$4,229,200.00	$14,225,443.59

[1]Improvement appropriation.

large number of what are known as "motorways" and "trailways," providing more simple and inexpensive means of travel than the regular development roads and the regulation trails, were constructed in place of or supplementing the latter. The total mileage of all construction is shown in Table III.

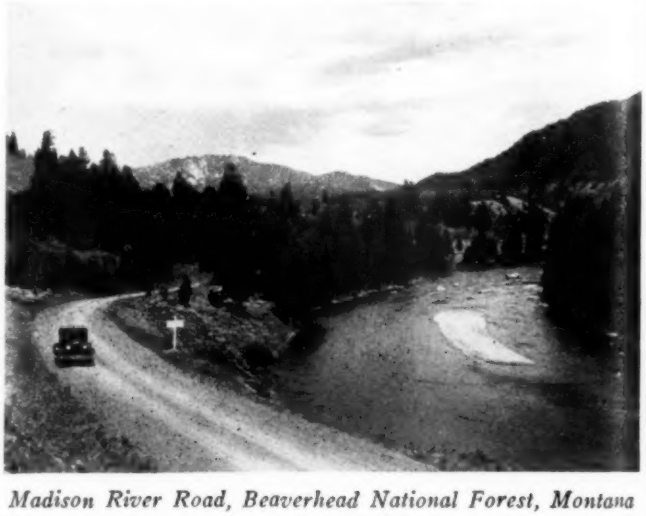
Alpine Scenic Highway, Wasatch National Forest, Utah

Under the regular procedure $12,500,000 was authorized for the fiscal year 1931 for the construction of forest roads and trails. Of this amount $9,500,000 was provided for forest highways and the remaining $3,000,000 for development roads and trails. Under the legislation to increase employment, enacted December 20, 1930, an additional $3,000,000 was appropriated for the construction of forest highways, and the same amount for the construction of development roads and trails. While the $9,500,000 originally authorized for forest highways could be expended upon any road included in the forest-highway system, the expenditure of the $3,000,000 forest-highways emergency appropriation was restricted by the law to sections located within the forest boundaries.

TABLE V—CONDITION OF FOREST-ROAD FUNDS ON JUNE 30, 1931

Fund	Appropriations	Expenditures	Balance
10 per cent	$ 7,954,034.81	$ 7,559,239.76	$ 394,795.05
Section 8....................	10,000,000.00	9,968,691.22	31,308.78
Federal forest-road construction	9,000,000.00	9,000,000.00	....
Forest highways ..	48,555,000.00	45,786,060.57	2,768,939.43
Forest road development	29,500,000.00	29,295,282.09	204,717.91
Improvement	4,553,000.00	4,549,622.21	3,377.79
Total	$109,562,034.81	$106,158,895.85	$3,403,138.96

Both of the $3,000,000 appropriations were to be expended or placed under contract before July 1, 1931, under the terms of the act. The forest-development road money was allotted to many small projects, with results that have already been recounted. In spite of the fact that the construction went on in the winter season and consequently under bad-weather conditions, very satisfactory results were obtained.



Madison River Road, Beaverhead National Forest, Montana

The forest-highway appropriation under the act of December 20, 1930, is being expended upon major road

Elk Mountain Road, Monongahela National Forest, West Virginia

projects by the Bureau of Public Roads. Since practically all such projects are handled by contract it is necessary in each case to make a location survey and to prepare plans and estimates. Naturally this prevented starting the construction immediately. *However, the total amount was under contract by July 1 and will be expended during the present field season.*

Because of difficulties encountered in purchasing road equipment and the fact that an unusually large amount of such equipment would have to be obtained before the beginning of the field season, the men in charge of the road work in the several regions were called to Washington in December for a general conference. After discussing the value and use of the various kinds of equipment, decisions were reached on the specifications to be used and the amount of equipment to be ordered. Purchases of road machinery for all the regions were consolidated and handled by the Washington office. This effected a considerable saving.

The meeting also brought about a correlation of construction ideas and methods and better use of machinery during the various steps of construction. Marked advances have been made in the construction methods for minor roads, particularly in the use of machinery for practically all the work. The machinery used is larger and more powerful than formerly and is better adapted to the special conditions encountered. Equipment intended for other purposes has been redesigned and remodeled so as to adapt it to use in the character of construction involved for protection roads. All of this has greatly reduced the cost of minor-road construction. Present costs are from 50 to 75 per cent of what they were five years ago.

Last year's annual report recounted at some length the objectives that govern the planning of national-forest transportation systems and described the methods pursued in building up the plans for individual forests. The planning work is being pushed upon a number of the forests in each region, with particular stress upon those where the fire danger is greatest. A number of important questions have arisen which must be decided before the plans can be completely formulated. These questions are being given further careful study, and decisions will be made regarding them during the present year.

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Automobile Operating Cost *Curves Charted*

By R. G. Paustian

Junior Engineer, Iowa Engineering Experiment Station

TO the engineer interested in the economics of highway transportation, the material herein presented is of particular significance. In any determination of the total cost of highway transportation, it is always necessary to determine the cost of vehicle operation. The data and material presented in this discussion are of very recent date and should, therefore, be used in any determination of transportation cost.

In connection with any determination of the cost of transportation over a section of highway, there should be mentioned the possibility of determining, from an accurate traffic census, the "composite" car using that highway; and, from the accompanying diagram, the operating cost of such a vehicle. It is apparent that the "composite" car using a strictly rural highway might be much different than the "composite" car using a heavily-traveled inter-city highway. It might be enlightening to determine the error incurred, in these cases, by using the average operating cost of a "composite" car determined from state of national registration records.

"What does it cost me to operate my car?" This question is answered, to a more or less extent, in a recent publication[1] of the Iowa Engineering Experiment Station, an organization very active in the field of highway economics and motor vehicle transportation The writer has studied and analyzed these data, combined them with data taken from other publications, and presents herewith a diagram which shows cost of operating any automobile under various conditions. Acknowledgment is gratefully given to the Iowa Engineering Experiment Station and to R. W. Winfrey, T. R. Agg, and H. S. Carter for the use of the information contained in their publications.

Components of Operating Cost.—The information on operating cost in Bulletin 106 was obtained from the records kept by individual owners and several state highway departments. This material was assembled and grouped into classes representing the number of engine cylinders and the list weight of the car. Table 1, from Bulletin 106, in addition to this information, gives the makes of cars included in each group classification and indicates how the "composite" car was determined.

The cost data submitted by grouping the several components of the operating cost were assembled and grouped into certain so-called fixed and variable costs. Fixed costs, including license charges, garage rent, interest, and insurance, vary slightly with an increase or decrease in annual mileage. In this connection, it might be mentioned that a life mileage of 50,000 miles was assumed for all vehicles. Variable costs, including gasoline, oil, tires and tubes, maintenance, and depreciation, vary more or less directly as the annual mileage. The exact nature of the assumptions made in reducing the costs to a common basis may be found in the original publication.

TABLE 1—WEIGHT, LIST PRICE, MAKE, AND GROUP CLASSIFICATION OF CARS

	Class Limits		Cars in Table 14: Weight Range, lb.			Cars in Table 14: Factory List Price, $			Approx. Percentage, 1930 Iowa Registration
Weight Class	Min.	Max.	Min.	Max.	Avg.	Min.	Max.	Avg.	
Light 4	1500	2000	1558	1965	1703	355	680	415	31.21
Ford A (M4)	2000	2500	2050	2372	2199	395	625	493	12.55
Other Med. 4	2000	2500	2005	2500	2299	495	1248	728	13.44
Heavy 4	2500	3200	2510	3209	2646	495	1650	922	7.10
Light 6	2100	2700	2185	2700	2535	525	1950	861	16.47
Medium 6	2700	3300	2703	3280	2938	875	1595	1179	9.30
Heavy 6	3300	4500	3300	4113	3506	1095	2685	1426	7.97
Light 8	2800	3500	2890	3070	2934	995	1465	1339	0.54
Med'um 8	3500	4200	3545	4100	3798	1695	3045	2320	0.72
Heavy 8	4200	5400	4285	4632	4603	3185	3496	3374	0.70
Composite car	......	......	......	......	2350	......	......	767	100.00

Weight Class	Makes of Cars Included in Each Class
Light 4	Ford T, Chevrolet, Star.
Ford A (M4)	Ford A.
Other medium 4	Chevrolet, Chrysler, Dodge, Maxwell, Whippet.
Heavy 4	Hupmobile, Nash, Plymouth, Overland, Reo, Willys-Knight.
Light 6	Chandler, Chevrolet, Chrysler, Dodge, Durant, Essex, Falcon-Knight, Franklin, Nash, O'dsmobile, Overland, Oakland, Pontiac, Star, Studebaker, Whippet
Medium 6	Buick, Chrysler, Columbia, Dodge, Falcon-Knight, Graham-Paige, Jewett Hudson, Hupmobile, Nash, Oakland, Oldsmobile, Reo, Studebaker, Willys Knight.
Heavy 6	Buick, Dodge, Hudson, Nash, Packard, Peerless, Studebaker, Willys-Knight.
Light 8	Roosevelt, Marmon, Oldsmobile.
Medium 8	Cadillac, Hupmobile, Nash.
Heavy 8	Cadillac.

[1]Winfrey, R. W., *Automobile Operating Cost and Mileage Studies*, Bulletin 106, Iowa Engineering Experiment Station..

TABLE 2—EFFECT OF ROAD CONDITION ON VARIOUS ITEMS OF OPERATING COST

Item of cost	Sum expended for the item when using high type roads	Sum required for equal mileage on intermediate type roads	Sum required for equal mileage on low type roads
Gasoline	$1.00	$1.20	$1.47
Oil	1.00	1.00	1.00
Tires and tubes	1.00	2.22	2.90
Maintenance	1.00	1.20	1.47
Depreciation	1.00	1.10	1.24
License	1.00	1.00	1.00
Garage	1.00	1.00	1.00
Interest	1.00	1.00	1.00
Insurance	1.00	1.00	1.00

Effect of Road Condition on Operating Cost.—It is very evident that the type and condition of road surface will have some effect upon the cost of motor vehicle operation. Everyone can realize that it is much more economical to operate an automobile over a smooth concrete pavement than over a rough muddy earth road. An interpretation of available research data led to an estimate of the effect of road conditions on operating cost.

by T. R. Agg and H. S. Carter in 1928.[1] Their estimates were made upon the basis of several assumptions in regard to the seasonal variation in road condition, the relative rate of tire wear on various types of roads, the effect of road condition on vehicle maintenance, the effect of road condition on vehicle depreciation, and the variation in gasoline consumption on differeent types of roadway surfaces. The effect of the variables upon the cost of operation is shown in Table 2, taken from this publication.

Use of Diagram.—Since the operating cost reports mentioned in the first part of this discussion applied to cars operated on all types of road surfaces, it may be assumed that the general averages given in Bulletin 106 are indicative of the cost of operation on intermediate type roads. Application of the values given in Table 2 to the various items in these operating costs then gave the cost of operation of various classes of motor vehicles on low, intermediate, and high-type roads for annual mileages of from 3,000 miles to 18,000 miles. The values thus obtained were then plotted, with the result shown in Fig. 1.

With this diagram, it becomes possible to determine the cost of operation of any class of automobile on any type of road surface for any given annual mileage. As is apparent, the diagram consists of two sets of curves. One, a group of ten curves, represents the relationship between the cost of operation and annual mileage for various classes of cars; the second, a group of three curves, indicates how the type of road surface affects the cost of operation. The annual mileages are given on the lower horizontal scale.

To use the diagram: Enter the diagram on the lower horizontal scale with a given annual mileage, go vertically upward until the desired vehicle curve is intersected, move horizontally either to the right or left until the desired road-type curve is met, and read the cost of operation directly above this point.

Example.—Suppose, for example, that it is desired to know the cost of operating a vehicle belonging to the "Heavy 4" class over intermediate-type roads; the annual mileage is estimated at 10,250 miles. With this annual mileage, enter the diagram on the lower horizontal scale, go vertically upward until the "Heavy 4" curve is intersected, move horizontally to the left to the "intermediate-type" surface curve; the operating cost of 7.1 ct. per mile is read directly above this point.

It is believed that the diagram and the material presented will be of use and of value to many individuals. Anyone driving a car is interested in knowing how much the operation of that vehicle is costing him; fleet owners and operators seek the same information. The diagram is simple enough to be used by anyone.

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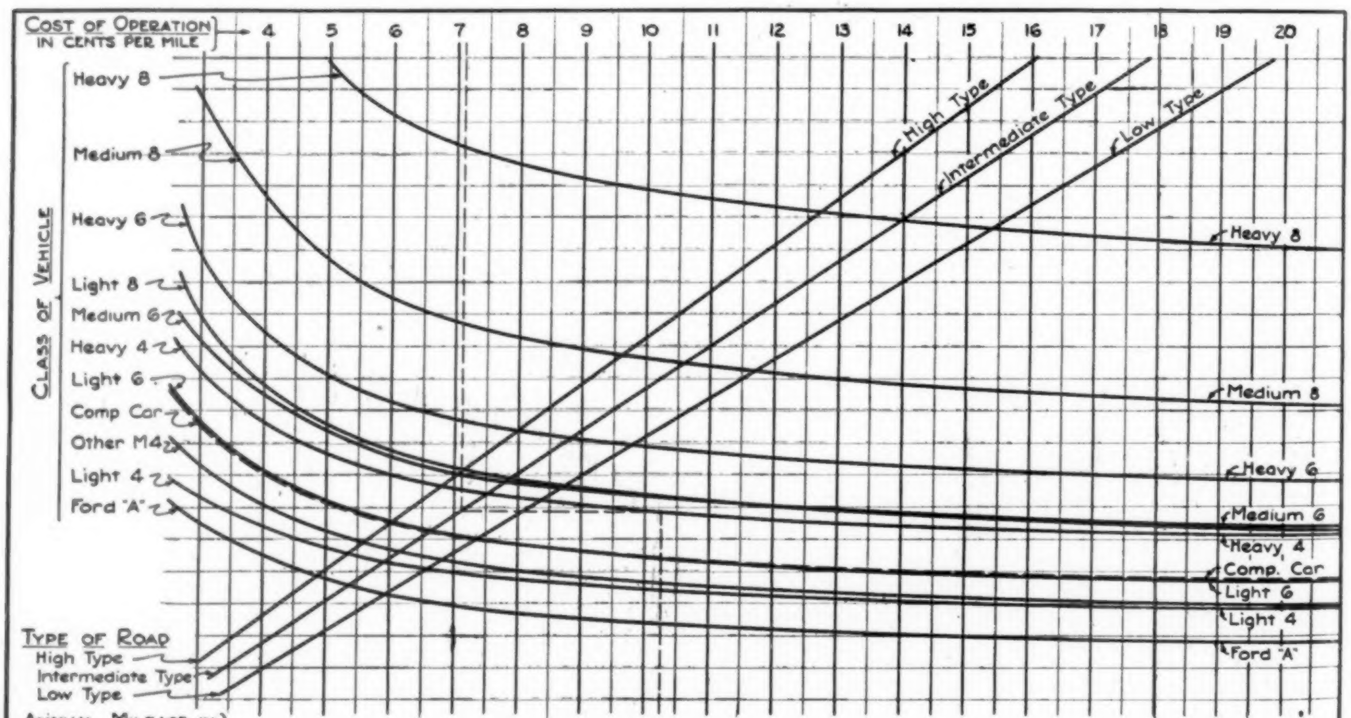
It is cheaper to oil a road for dust prevention than not to oil. The oiling saves the metalling.

[1] T. R. Agg, H. S. Carter, *Operating Cost Statistics of Automobiles and Trucks*, Bulletin 91, Iowa Engineering Experiment Station.



Garage Problems

By K. M. Dimmich
Benton County Highway Superintendent, Fowler, Indiana

THIS subject could be handled in many different ways; however, I shall limit my discussion to why and how Benton County secured a highway garage.

Conditions in our county are quite favorable to a central garage. The county is approximately square, being eighteen by twenty-three miles in dimensions, and Fowler, the county seat, is located near the center. For several years I had visions of a garage and in my annual report to the county commissioners for at least two years I had recommended that the county should own a plot of ground and a garage, which would provide a place to store and house our tools, materials, and equipment, and serve as a central starting place for each day's operations. The central commissioners would read these reports and approve them, but we failed to get a garage. The recommendation was apparently forgotten as soon as the meeting ended. I suppose I was partly to blame for the plans not being carried out, for I have a habit of recommending a thing and letting it go at that. I don't like to be nagging the commissioners for a particular thing which I have recommended, for I feel as though the board sees the necessity for it and should act accordingly as they see fit.

We had gathered up quite an assortment of bridge material, old tools, etc., and had them parked along the road just out of town. One Sunday night in 1925 two cars met along this miscellaneous assortment of tools and equipment rather late or early the next morning. The drivers were young men who apparently had been out late and the lights of one car blinded the driver of the other and he ran into this assortment of equipment. In the end the county paid a repair bill of some $128 and also agreed to provide storage for this material and the county trucks. Prior to this time we had been keeping our trucks in a garage paying $5.00 per month for each truck and buying our gasoline and oils from the proprietor.

The oil and gas men up to this time refused to give the county any direct price on their products. We bought our own gasoline pump and a 550 gallon tank. Now we buy direct and make quite a saving on not only our gas, oil, etc., but save the storage charges and do a part of our minor truck repairs. We saved $577.55 on our gasoline alone in 1931.

Since the board of commissioners had agreed to build a garage, the next thing to do was to find a suitable location and prepare plans. I was told to get up some rough plans for what I thought the county needed, all of which I did. The board, however, turned down my specifications because the cost was too high.

The board bought one-half block of ground, well located, for $700 and finally let a contract for a garage to be built of brick, costing as follows: Building, $3,608.65; heating plant and wiring, $632.00, totaling $4,240.65. The building together with the lots made the total cost $4,940.65. We moved in October 1, 1925.

This garage is 84 by 26 ft. with a door for each of four stalls, also a door to an unheated room of 26 by 24 ft. I was glad to get even this kind of a garage, although I could see that we were short of space and, as the building was planned, there was too much lost space. We started off, however, apparently feeling fine and well satisfied. You know, it is a good idea to at least appear satisfied in some of our work. I still felt that I was right in the size and type of garage originally recommended, which included a floor space of 80 by 60 ft. with one door in each end. This would call for only two doors to keep up, instead of five as is now the case, with a driveway through the center of the building, a heating plant in the basement, and a stock room and an office on the main floor. In the present building we have the four stalls, a small office, coal bin, and hot water heating plant for the office.

We got along with this storage space until 1930 when our crowded condition became quite a problem, since we had been purchasing more trucks and equipment all during this time. We had four trucks and one pick-up to start with and in 1930 we had six trucks, four tractors, and a concrete mixer to house. Early in 1930 I recommended building a shed or garage with a work shop in it where we could house our tools and do repair work without having to leave a truck outside to complete the job or without moving an unfinished repair job out to put a truck inside. Our board did nothing until their November meeting when I brought the question up again and they told me to hire carpenters and build what we had agreed upon, which was a shed similar to one the State Highway Commission had built there the year before. They agreed to let me build it with my own men and I soon found it was a bigger job than I had anticipated. I had six men, none of whom knew very much about carpentering. We went at it, however, and took care of our roads besides.

At the December meeting of the board, I was rather proud of the fact that we had the building erected, painted, and ready to show to them. It measured 84 by 24 ft. It pleased the board so well that they let me put a concrete floor in the whole building, instead of just the work shop as at first planned. The cost of this building without concrete floor was about $900.

This new garage has four 10-foot stalls, two 12-foot stalls, and a work room 20 by 24 ft. with a stove for heating. In the work shop we have a bolt rack with a good assortment of bolts, etc.; also angle irons, rods, and other materials for the repair of drags, and snowplows; electric drill; forge; anvil and a fair assortment of small tools. We repair our drags, graders, snowplows, etc. We built one snowplow this winter that we think will meet most any situation to which it can be subjected, but have had no snow to try it out as yet.

Most of our truck repair work is done at a first-class garage in Fowler as we do not yet keep a mechanic in our own garage. I believe there could be some plan worked out whereby it would pay the county to keep one.

Acknowledgment.—A paper presented at the Eighteenth Annual Purdue Road School, January 25, 1932.

Principal Gas Tax Diversions

Florida—Schools and general fund, 1 cent out of 7.
Georgia—Equalization fund for public schools.
Louisiana—Education and harbors, divide 1 cent.
Massachusetts—Department of public works projects, 1 cent.
New York—Portion New York City general funds.
Oklahoma—Emergency relief fund, 1 cent.
Texas—General fund and school.
Idaho—General fund of state.

BEFORE

Condition of old state road over Yellow Jacket hill between Durango and Pagosa Springs, Colorado, during wet weather. Photo by U. S. Bureau of Roads.

A section of the new Federal Aid highway over Yellow Jacket hill recently opened to traffic. This can be traveled in any sort of weather. Photo by U. S. Bureau of Roads.

AFTER

A bad railroad-highway grade crossing. There is a reverse curve on the road and the vision of the railroad track is obscured by a high bank. Photo by U. S. Bureau of Public Roads.

The separation of the grades of the railway and roadway by means of an under or over-crossing eliminates all danger of collision between train and motor vehicle. Photo by U. S. Bureau of Public Roads.

The Road Builders' News

Annual Meeting of Road Builders Held in April

The annual meeting of the American Road Builders' Association, at which new officers are installed and plans for the coming year outlined, will be held April 28 and 29 in Washington, D. C., the headquarters of the association.

A new feature this year will be the president's reception which will assemble road builders from all parts of the country at the Willard Hotel in Washington on April 28 at 8:00 p. m.

Meetings of the City Officials' Division and the County Highway Officials' Division boards of directors will be held on Friday, April 29. In the afternoon the incoming board of directors of the American Road Builders' Association will discuss plans for the year beginning with a luncheon.

Men who will take office at the coming meeting are:

T. H. Cutler, chief engineer, Missouri State Highway Commission, Jefferson City, Mo., is the presidential nominee to lead next year's work of the American Road Builders' Association, according to the report of the Nominating Committee of the Association.

The City Officials' Division has nominated Robert B. Brooks, director of streets and sewers, St. Louis, Mo., for the presidency of that Division. The man chosen to lead the County Highway Officials' Division is W. O. Washington, county engineer, Cameron County, Brownsville, Texas.

Other nominees slated by the Committee on Nominations are:

AMERICAN ROAD BUILDERS' ASSOCIATION

For Vice-Presidents

E. L. Benedict, vice-president, National Steel Fabric Co., Pittsburgh, Pa.; J. W. Barnett, chairman, Georgia State Highway Board, Atlanta, Ga.; G. C. Dillman, state highway commissioner of Michigan, Lansing, Mich.; Stanley Abel, supervisor, Fourth District, Kern County, Taft, Calif.

For Treasurer

James H. MacDonald, consulting road and paving expert, New Haven, Conn.

For Directors

J. H. Cranford, president, Cranford Paving Co., Washington, D. C.; A. W. Dean, chief engineer, Massachusetts Department of Public Works, Boston, Mass.; E. J. Harding, managing director, Associated General Contractors of America, Washington, D. C.; J. S. Helm, general manager, Asphalt Sales Department, Standard Oil Co. of New Jersey, New York, N. Y.; A. E. Horst, secretary-treasurer, Henry W. Horst Co., Philadelphia, Pa.; G. B. Sowers, commissioner of engineering and construction, Cleveland, Ohio; C. M. Upham, engineer-director, American Road Builders' Association, Washington, D. C.

CITY OFFICIALS' DIVISION

For Vice-Presidents

D. T. Corning, chief, Bureau of Highways, Philadelphia, Pa.; R. Keith Compton, director of public works, Richmond, Va.; R. H. Simpson, chief engineer, Department of Public Service, Columbus, Ohio; J. M. Tippee, city engineer, Des Moines, Iowa.

For Directors

W. E. A. Doherty, engineer of construction, Bureau of Highways, Philadelphia, Pa.; M. O. Eldridge, assistant director of traffic, Washington, D. C.; O. Laurgaard, city engineer, Portland, Oregon; M. M. O'Shaughnessy, city engineer, San Francisco, Calif.; A. T. Rhodes, city councilor, Leominster, Mass.; W. E. Sheddan, city engineer, Jacksonville, Fla.; N. L. Smith, associate engineer of Baltimore, Md.

COUNTY HIGHWAY OFFICIALS' DIVISION

For Vice-Presidents

H. B. Keasbey, county engineer, Salem County, Oregon; C. E. Burleson, county engineer, Pinellas County, Clearwater, Fla.; H. G. Sours, county engineer, Summit County, Akron, Ohio; G. W. Jones, county superintendent of highways, Los Angeles County, Los Angeles, Calif.

For Directors

J. T. Bullen, parish engineer, Caddo Parish, Shreveport, La.; J. A. Bromley, county roads engineer, Anne Arundel County, Annapolis, Md.; B. T. Collier, county engineer, Coahoma County, Clarksdale, Miss.; C. W. Deterding, county engineer, Sacramento County, Sacramento, Calif.; Don Heaton, county surveyor, Benton County, Fowler, Ind.; Roy Jablonsky, county surveyor, St. Louis County, Clayton, Mo.; G. C. Wright, county superintendent of highways, Monroe County, Rochester, N. Y.

Fourteen other directors of the Association and also of the Divisions carry over. The new directors are elected for a three-year term.

Progress of Emergency Road Appropriation in Congress

Backed by the American Road Builders' Association and the American Legion and the other organizations affiliated with the movement to find jobs for the unemployed, the emergency road appropriation bill for $132,000,000 has passed the House and is now before the Senate in Congress. Support of this bill has been actively given by the National Employment Commission of the American Legion which is working in cooperation with the American Federation of Labor, the Association of National Advertisers and the American Legion Auxiliary.

"Unless this bill becomes a law," says H. L. Stevens, Jr. in a recent statement to the press, "thousands of men will be added to the ranks of jobless, because employers all over the country will be forced to discharge men now engaged in road work.

"Passage of the emergency highway construction bill at this time will be of most immediate benefit to the country at large, and in urging its adoption the American Legion feels that it is putting its strength behind an economically sound and definite measure of unemployment relief.

"Our greatest effort now is to put jobless men back to work, and the records of the United States Bureau of Public Roads show that from 75 to 90 per cent of the average dollar spent in highway construction goes ultimately to the wage earner, either directly or through employment in industries furnishing materials. No other type of public improvement gives such a large share of the expenditure to labor, and distributes its benefits so generally through the country."

Senator T. L. Oddie of Nevada, chairman of the Senate Committee on Post Offices and Post Roads, has expressed the opinion that the bill will pass the Senate by a good majority. The signature of President Hoover will then be needed to make the bill a law.

Grubb Discusses Advance Planning for an Ohio County

At a special meeting called by County Surveyor Howard Collett of Clinton County, Ohio, to discuss advance county highway planning 300 people interested in the future of county roads gathered at the court house in Wilmington, Ohio, on March 14 to hear Chas. E. Grubb and other speakers. Mr. Grubb is executive engineer of the County Highway Officials' Division of the American Road Builders' Association.

Mr. Grubb stressed the importance of systematic local planning and gave details of what is being done in many counties in the country.

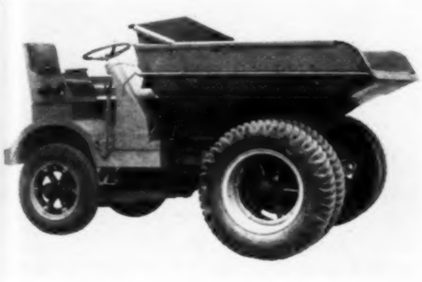
"Systematic planning will aid county officials," declared Mr. Grubb, "in avoiding excessive right of way costs, heavy reconstruction costs and the misuse of land. A schedule for providing highways to connect business centers is laid out, and a construction program to fit in with state and federal aid roads is determined.

"Business-like procedure by all governments," declared Mr. Grubb, "will be the order of the coming decades. Limited public treasuries will not permit of: excessive road mileage, roads useless because of bad location, correction of avoidable mistakes or the premature obsolescence of roads, bridges, buildings and other public works. Unless the taxpayer can feel that he is getting his money's worth he will deny himself needed public improvements for which he can well afford to pay."

New Equipment and Materials

Koehring Brings Out New Wheel Dumptor

A new dirt hauling unit has been brought out by the Koehring Division of the National Equipment Corporation, Milwaukee, Wis. This new unit—the Koehring wheel dumptor—has a load carrying capacity of 4 cu. yd. It com-



Koehring Wheel Dumptor

bines a relatively small load on large tires with excess motor power. It has a short wheelbase and the advantages of instantaneous front gravity dump and spreading type body.

Here are some of the outstandingly features claimed for the dumptor:

Three speeds forward and three speeds reverse. Dumptor can shuttle on most hauls; with the high reverse speeds, it also eliminates turns and saves many seconds each trip.

Constant mesh transmission. Specially designed to facilitate shifting. Quicker gear shifting, and elimination of danger of burring gears.

Instantaneous gravity dump and kick-out pan; dumping angle 90 deg.; automatic kickout pan insures clean dump.

Exceptionally short turning radius; the 85¼ in. wheelbase making it possible to turn the machine in a circle 26 ft. in diameter.

Wheel equipment is interchangeable from the pneumatic lug type tractor tires to 24 in. steel wheels equipped with two rows of spade lugs.

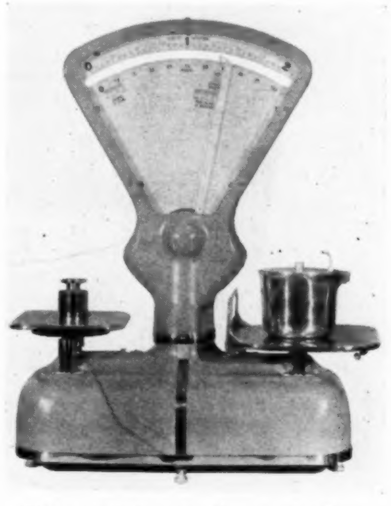
Other construction details such as pressure lubricated clutch throwout bearings; full pressure lubrication of all motor parts; packless water pump; only one grease cup on entire power unit; two air cleaners in series; and 4 in. final drive axles of chrome vanadium steel,—are examples of the special engineering designed into the Dumptor to cope with the rigors of dirt hauling.

Aggregate Determination Scale

Quick and accurate determination of the specific gravity, surface moisture and sieve analysis of sand and gravel used in cement batching is stated to be available with the new Toledo determination auto-gage. This scale, introduced by the To-

ledo Scale Co., Toledo, O., eliminates all mental computations on the part of the operator. Simple in operation, at the same time, it sets new standards of speed and efficiency.

For the determination of specific gravity, the process is as follows: After wiping the sample bucket clean, inside and out, the bucket and its lid are placed on the scale platter, and the weight is placed on the weight platter. Surface dry but saturated sand or gravel is then poured into the bucket until the "Weight of Sand" section of the chart reads 2.67. 2.67, the average specific gravity of sand, is used to obtain a standard sample of 2 lb. The third step is to pour water into the bucket to not less than ¼ in.



Toledo Determination Auto-Gage

from the top, meanwhile stirring the sand to release air. Finally, after putting the lid on tightly and removing any water on the outside, the specific gravity will be accurately indicated on the "Specific Gravity" chart.

A similar process is followed in measuring surface moisture. The one difference is the substitution of the figure obtained for specific gravity in the first operation in place of 2.67. After filling with water, the percentage of moisture will be indicated on that portion of the chart. Otherwise the same routine is followed.

For sieve analysis, a scoop with a shoe and a scoop weight are furnished. When these are placed on the scale platters, the indicator rests at zero. Material should be poured into the scoop to obtain a reading of 100 per cent. Having obtained a sample of known weight, representing 100 per cent, the material is screened and classified. Placed in the scoop one lot at a time, the percentage of each will be indicated on the percentage graduation.

Ditwiler Offers Perfected Spreader

The Hercules-Ditwiler trailer type spreader now being made by the Ditwiler Manufacturing Co. of Galion, O., embodies several new features. It is stated to be adapted for spreading chloride for dust prevention, for spreading salt, sand, cinders or chloride on icy streets, for spreading chips, slag or other covering on penetrated stone—and in fact for any spreading of light aggregates 1 in. or smaller on roads, in construction or maintenance.

The spreader is operated by its own air-cooled motor and width of spread, 6 to 30 ft., is regulated by the speed of the motor and is stated to be always uniform regardless of the speed of the truck. The amount of aggregate spread depends on truck speed, and can be regulated very accurately and an extremely even spread be obtained. The Hercules-Ditwiler spreader is designed especially for use with lighter dump trucks, but by a simple adjustment it can be used just as readily with larger trucks.

Agitator blades in the feed hopper give the material a rotary motion and break up lumps which may have formed. An additional hopper is supplied for use in spreading chloride from non-dumping truck bodies. This spreader requires only a small permanent attachment on trucks and it can be attached to each truck in turn in less than a minute. Adjustable legs are used to support the front of the spreader when detached.

The weight of this spreader, engine, hoppers and all, is 535 lb. In operation this weight is supported in part by the truck and in part by the rear wheel on a standard auto tire. The spreader trails back and is stated to manipulate perfectly at all truck speeds, in operation or in moving from place to place.

Hercules-Ditwiler Spreader

Fill-Jetter

A machine for forcing water into earth fills for the purpose of settling the fills has been brought out by the C. H. & E. Manufacturing Co., Inc., 120 East Mineral St., Milwaukee, Wis.

The machine consists of three jets spaced on 5-ft. centers, with a maximum working depth of 8 ft. 6 in. Extra lengths of pipe can be attached to the jet if greater depth is required. The jets are equipped with removable, hardened steel nozzles which have one hole in the end and four holes on the sides. The jets are raised and lowered by large hand wheels. Jets are operated at 40 to 60 lb. pressure.

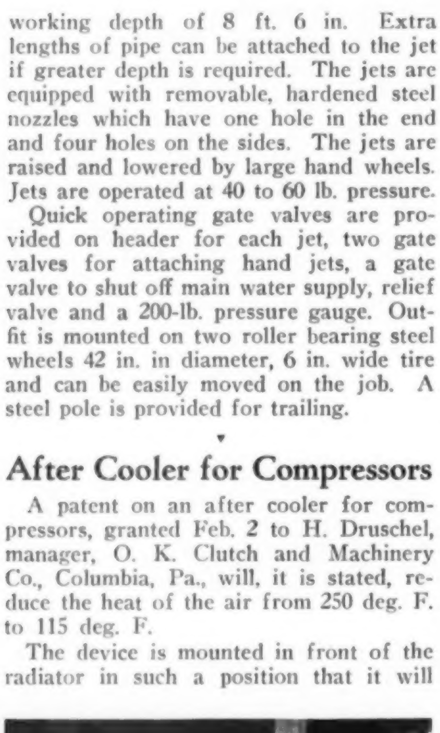
C. H. & E. Fill-Jetter on Hartmann-Clark Brothers Co. Work at Beecher City, Ill.

Quick operating gate valves are provided on header for each jet, two gate valves for attaching hand jets, a gate valve to shut off main water supply, relief valve and a 200-lb. pressure gauge. Outfit is mounted on two roller bearing steel wheels 42 in. in diameter, 6 in. wide tire and can be easily moved on the job. A steel pole is provided for trailing.

After Cooler for Compressors

A patent on an after cooler for compressors, granted Feb. 2 to H. Druschel, manager, O. K. Clutch and Machinery Co., Columbia, Pa., will, it is stated, reduce the heat of the air from 250 deg. F. to 115 deg. F.

The device is mounted in front of the radiator in such a position that it will not affect the cooling of the water in the radiator but at the same time will cool the air. It is a very simple device and can be used any time independent from the tank, where the air will be used direct; or in other words, with this device there are two ways of getting air from the compressor, namely, direct from the tank without letting it pass through the after cooler or letting it pass through the after cooler. It is stated that the after cooler will be particularly useful in hot weather as it will effect a large saving on hose as hose is easily deteriorated by the heat of the air and will give cooler air, which will increase the efficiency of the air of the tools used.



After Cooler on Compressor

New Improved Level-Transit

A specially designed "Level-Transit" for the engineer and contractor is announced by the David White Co., Inc., Milwaukee, Wis. The most important improvement is the unusual strength and construction of the standards which are cast in one piece around the upper body and which is stated to insure that the instrument will withstand more rough handling and still stay in adjustment.

Instrument in Level Position

The instrument has the following outstanding features: The telescope has a magnifying power of 25 diameters which enables the reading of a rod at a distance of approximately 1,000 ft. It is also possible to take a focus as close as 4½ ft. from the center of the telescope. In order to change the instrument from the level to the transit position, it is only necessary to release the two levers. It is equipped with a vertical arc so that the angles above and below the horizontal plane can be easily read. It is equipped with two sensitive level vials. One underneath the telescope and the other set a right angles on the body of the instrument. This insures rapid leveling. The instrument is equipped with a large shifting center which permits the instrument to be moved in any direction over a given point without disturbing the adjustment.

An interesting booklet has been prepared for the contractor and the builder entitled "How to Lay Out Building Lots Accurately." This booklet will be sent upon request.

New Spreader

A new spreader for distributing gravel, stone, sand, cinders and calcium chloride has been brought out by the Efficient Road Machinery Co., Inc., Syracuse, N. Y. In summer the same equipment is used to distribute calcium chloride on dirt roads as a dust control.

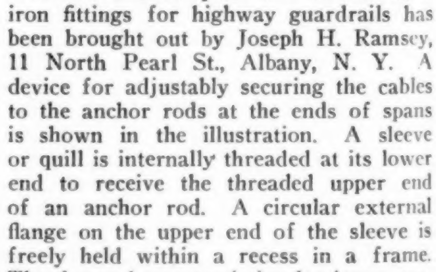
G. S. C. Hi-Speed Spreader

This unit also can handle any size of material up to No. 3 crushed stone. The depth of spread can be controlled to range from a light sprinkle to a layer several inches deep. The width of spread ranges from 1 to 8 ft. as desired. The spreader fits any truck without using special adapters or boring a single hole. It can be completely attached or detached by one man in 15 minutes.

It is stated to operate with equal efficiency at either the maximum or minimum speed of the truck on which it is mounted. It interferes in no way with the operation or capacity of the truck. After a tarring or oiling operation the laying of the seal coat or dryer can be accomplished by operating the truck backwards if desired. The control of the spreader can be handled by the truck driver by the aid of one rope. If an extra man is used he stands on a platform for that purpose at the rear of the truck.

New Guardrail Fittings

A new and complete line of malleable iron fittings for highway guardrails has been brought out by Joseph H. Ramsey, 11 North Pearl St., Albany, N. Y. A device for adjustably securing the cables to the anchor rods at the ends of spans is shown in the illustration. A sleeve or quill is internally threaded at its lower end to receive the threaded upper end of an anchor rod. A circular external flange on the upper end of the sleeve is freely held within a recess in a frame. The frame has a semi-circular inner sur-



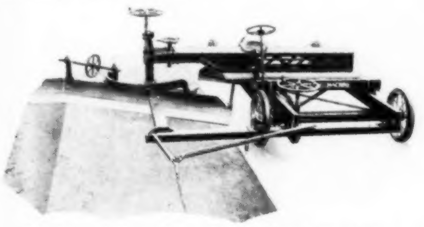
Device for Securing Cables to Anchor Rods

face for free engagement with the looped end of the guardrail cable. A hex-shaped section is cast on the sleeve so that it may be turned with a wrench upon the threads of the anchor rod and thus tighten or loosen both the upper and lower cables simultaneously without rotating the frame. The device equalizes the strain of a collision upon both cables. Other new items in the line include malleable iron guardrail posts, off-set brackets, turnbuckles, cable splices, anchors, anchor rods, etc.

Improved Moritz Shoulder Finishing Machine

The 1932 Moritz shoulder finishing machine of the Moritz-Bennett Corporation, Effingham, Ill., has many new and important improvements. The design of the machine with unique and patented feature of pull drawbar on outside of frame remains the same and a stronger and heavier frame gives additional rigidity and weight.

A most important improvement is the new mold board couple bar (from rear inner end of mold board to main frame). This exclusive Moritz feature reverses side thrust action when blade is under heavy load. This, in combination with direct drawbar pull on outside of frame and weight of machine on solid rubber tired wheels eliminates side draft and side thrust when blade is under extremely heavy load.



Moritz Shoulder Finishing Machine

Other improvements are: New sectional boom that accommodates various lengths of blades for finishing shoulders up to 11 ft. in width with all four wheels riding on pavement. New positive (screw type) adjustment for sloper blade. New auxiliary blade for cleaning pavement. Many other additional improvements and refinements.

New Hercules Engines

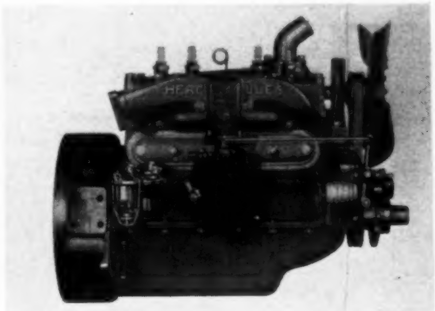
The Hercules Motors Corporation of Canton, O., in announcing the IX series engines and power units has added the following models to its present line of heavy duty 4 and 6 cylinder engines, thus giving a complete range of sizes of from 9 to 175 hp.:

Model	Bore	Stroke	Displacement
IXA	3	4	113.1
IXB	3¼	4	132.7

The two models are identical in general design and the majority of the parts are interchangeable; the only difference being in the bore sizes and the parts affected thereby. The maximum torque of the IXA is 76 lb. developed at from 1400 to 2400 r.p.m. and on the IXB is 90 lb. developed from 1400 to 2300 r.p.m. Both models peak at 3200 r.p.m., the IXA developing 39½ lb., the IXB 46½ hp. at this speed.

To meet present-day operating conditions calling for sustained high speed, special consideration has been given to valve cooling. The engines and power units are equipped as standard with a No. 5 standard S. A. E. bellhousing, but the No. 4 and No. 6 can be supplied upon request. Standard practice includes thermo-syphon cooling, but water pumps are available if specified. Either down-draft or up-draft manifolds are optional.

Lubrication is of the full force feed type to the main bearings and connecting rod bearings. The pump is located beneath the center main bearing and driven from the camshaft by helical gears. The shafts and gears of the oil pump are case-hardened, insuring long life to this



Manifold Side of Hercules 1X Heavy Duty Engine

unit. Oil pressure can be adjusted easily to suit operation requirements.

As in all Hercules engines, the IX series have the crankcase cast integral with the block. The crankshaft is 2 in. in diameter at the three main bearings, of which the front bearing is 1 9/16 in. long, the center bearing is 1⅝ in. long and the rear bearing 1⅝ in. long. The connecting rod bearings are 1¾ in. in diameter and 1⅛ in. long, and the center length of the connecting rod is 6 9/16 in.

The pistons normally are of cast iron and carry three rings above the pin. The lower of these rings is of the oil regulating type. The compression rings are ⅛ in. wide and the oil rings 3/16 in. Piston pins are of nickel-molybdenum steel and are ⅞ in. in diameter. Each pin is securely locked in its connecting rod by a clamp bolt, and operates in two hard cast bronze bushings in the piston. Aluminum pistons can be supplied.

The camshaft is on the right hand side, supported by four bearings 1 7/16 in. in diameter. The front bearing is 1 3/16 in. in length, the intermediate 9/16 in. in length and the rear bearing 1 in. in length.

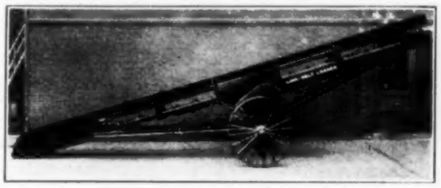
The engines have L-head cylinders and the valves are 30 deg. seat. The exhaust valves have a clear diameter of 1⅛ in. and the intake valves 1¼ in. They are operated by mushroom type tappets of steel construction with cast iron face.

New Link-Belt Portable Flight Conveyor

In broadening the scope of their portable conveying machinery line, Link-Belt Co., Philadelphia, Penn., have brought out the Link-Belt "bituminous type" portable flight conveyor.

Complete specifications show the adaptability of this machine to handling bituminous coal, coke and other lumpy materials, as well as fines.

The length of the conveyor is 21 ft., 26 ft. or 31 ft. centers. The frame is made of steel angles, channels and heavy plates, hot riveted. Heavy steel plate re-



New Link-Belt Portable Flight Conveyor

inforcement at the foot. The carrier is made up of two strands of C-188 malleable iron and steel combination Link-Belt (combined strength of 28,000 lb.) to which flights are fastened every 15¾ in. The flights are cupped to pick up the material. The chain speed is 126 ft. per minute. The trough is made of copper bearing steel to resist corrosion and wear. The drive is a 5 hp. (or 3 hp. on 21 ft. centers conveyor) ball-bearing electric motor, with fused safety switch; or gas engine if desired. Two finished steel roller chain drives connect the motor with the head shaft, which is provided with a breaking pin hub. The bearings are bronze bushed and Alemite lubricated.

The power-operated hoisting mechanism consists of a conveyor boom that can be raised or lowered by power from the motor, this being accomplished by the mere movement of a conveniently-located hand lever. The minimum discharge height of the conveyors above the ground line is 8 ft.; the maximum discharge heights are 14 ft., 17 ft. 6 in. and 20 ft. 6 in. for the 21 ft., 26 ft. and 31 ft. conveyors, respectively.

The truck supporting frame is made of structural steel, while the 48 in. diameter by 4 in. tread wheels are fitted with Alemite lubricated roller bearings. The axles, made of steel, are of the swiveling type, easily adjustable for position, on 26 ft. and 31 ft. conveyors.

New Lubrication System

The new Alemite metromatic lubrication system announced recently by Alemite Corporation, Chicago, Ill., uses a pipe line arrangement whereby the lubricant is forced under high pressure to each bearing on the machine. A measuring valve, located on the pipe line near the bearing, discharges a predetermined amount of lubricant at each operation of the pump handle.

A short length of copper tubing conducts the lubricant from the measuring valve on the pipe line to the bearing, and it is the unique operation of these measuring valves that makes this system of lubrication so outstanding, it being stated that there is no condition under which the lubricant can by-pass into the line—it must go into the bearing. Also the measuring valves located on the pipe line

are connected in multiple, and as many branches as necessary can be taken off at any point where other bearings need to be supplied.

To operate the machine, merely pump up a pressure of 2,000 lb. in the compressor and then release the valve. This operation has done two things in the lubricating system. A new and measured shot of clean lubricant has been forced into each bearing, and the continued pressure has forced a new load of lubricant into all the vacuum chambers, thereby charging the measuring valves for the next discharge operation.

Differential Disc Spreader Announced

A new material spreading device has been announced recently by The Universal Crane Co., Lorain, O.

Differential Disc Spreader

The distribution of the material is by means of dropping the material onto a disc revolving in a horizontal plane. The power for revolving the disc is obtained through the traction on the ground of the two wheels supporting the spreader. These wheels are equipped with industrial size 6 in. x 9 in. pneumatic balloon tires and drive back through a standard automotive type of 4 pinion differential to the vertical shaft on which the distributing disc is mounted.

A major advantage claimed for this type of drive is its ability to spread dust and screenings as a binder on the first and second courses of large stone. It is said that the combination of the rubber tires and the differential action prevents any disturbance of the inter-locked stone surface, while giving an even, uniform distribution of material.

It is also claimed that the differential action, which compensates for difference in wheel speeds on curves, gives a spreading efficiency on curves and intersections equal to that on straight-away.

Due to the centrifugal force built up at the edge of the disc, materials are cast outward and downward, permitting a spread of approximately 16 ft. (30 ft. on anti-skid work), with materials hitting the surface with a force and at a sharp angle giving good penetration into the voids of the large stone.

The width of spread is dependent on the speed of the truck, while the density or pounds spread per square yard depends on the variable gate opening through which the materials are passed onto the disc. Adjustable baffles are provided to limit width of spread regardless of truck speed, also to insure good overlap along centerline on resurfacing operations.

In addition to spreading dust on new construction, the spreader has a wide application to surfacing and retreading operations, and to anti-skid work spreading sand, cinders, salt or chemicals on icy hills, curves and bad intersections.

The Differential disc spreader is completely equipped with hand rails and side steps on each side for the operator, with control levers on each side for manipulating the hopper gate opening, with a hand lever to control the draw bar connection to the trucks, which is adjustable to various truck heights and capable of being changed while in transit to keep the disc level at all times for uniform distribution of materials.

Davey Compressor Mounted on Cletrac

The Davey compressor has recently been adapted for mounting on the Model 15 Cletrac of the Cleveland Tractor Co., Cleveland, O. This provides a flexible combined unit whereby utilization of the compressor is available in very convenient form and does not interfere with the other uses of the tractor for pulling purposes.

The Davey compressor is of the vertical, two cylinder type, air-cooled. The Davey mounting is carefully engineered in all details to work properly with the tractor. The location is such that maximum accessibility and convenience in operation is provided. The drawbar is entirely clear for all operations of the tractor. The light weight of the compressor unit, 890 lb., does not affect the tractor balance and adds to the traction power.

The compressor drive is through the rear power take-off, employing heavy alloy steel drive shafts, and only one spur gear reduction, minimizing power loss between tractor engine and compressor. A special heavy duty ball bearing provides ample bearing capacity for the driving sheave. A conveniently located clutch permits the starting and stopping of the compressor at will. Heavy V-belts drive the compressor and absorb the pulsating torque thereby eliminating undue strain and wear on the tractor mechanism.

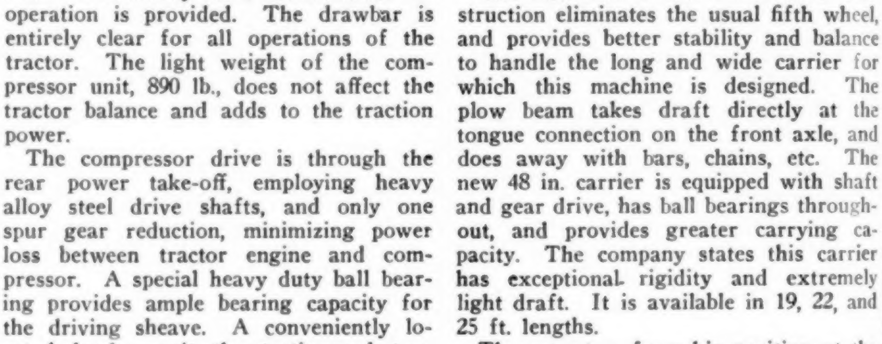
Davey Compressor on Cletrac

New Adams Elevating Grader Is Motor Controlled

A new heavy-duty elevating grader with new and exclusive features is announced by J. D. Adams Co., Indianapolis, Ind. This machine, known as elevating grader No. 11, has a distinctive new frame, front axle, and plow beam design, and 48 in. carrier. The carrier and plow controls are power operated.

The new frame and front axle construction eliminates the usual fifth wheel, and provides better stability and balance to handle the long and wide carrier for which this machine is designed. The plow beam takes draft directly at the tongue connection on the front axle, and does away with bars, chains, etc. The new 48 in. carrier is equipped with shaft and gear drive, has ball bearings throughout, and provides greater carrying capacity. The company states this carrier has exceptional rigidity and extremely light draft. It is available in 19, 22, and 25 ft. lengths.

The operator, from his position at the plow, has immediate control of the upper carrier, center of carrier, lower carrier,



New Adams Elevating Grader; Also Shows Power Control Box and Operating Levers

and plow which are all raised and lowered by power through enclosed gears. This is a new and valuable feature which is stated to take the hard work out of operating, save time and increase the efficiency of the operator. The inset in the illustration shows the power control box and operating levers. No. 1 is the master clutch lever which directs power to either the belt or the control box or both as desired. No. 2 raises and lowers the upper carrier. No. 3 raises and lowers the center of carrier. No. 4 raises and lowers the lower carrier. No. 5 raises and lowers the plow, which may also be operated by hand.

Power for operating the carrier and the controls is supplied by auxiliary engine or tractor power take-off as desired. The auxiliary engine drive is most popular and uses a new, improved McCormick-Deering power unit; a product of the International Harvester Co.

All-Steel Portable Tool Boxes

A recent addition to the line of Littleford Bros., 454 East Pearl St., Cincinnati, O., is an all-steel portable tool box. The Department of Highways of Cincinnati, O., has just added six of these tool boxes to its highway equipment and now has 22 all steel portable tool boxes.

The city keeps the boxes completely equipped and they are always ready for instant use. Such equipment is particularly valuable on emergency work. If a tool box is needed somewhere quickly, the truck operator can hitch it up himself and be on the job in less time than it formerly required to get a gang of men to load the stationary box onto a truck. This portable feature also leaves the bed of the truck available for other uses.

Formerly it was necessary to have a gang of men load the cumbersome stationary tool box into a truck. Very often a good many tools had to be taken out so that the box could be lifted. This took time. Now it is a matter of a few minutes to back a truck up to the portable box, fasten the coupling and be ready to go.

A truck can start out with two or three portable boxes in tow, drop them at proper locations and proceed with other work. The city has found that a plan of systematic shifting of tool boxes can be worked out to great advantage and a remarkable saving made.

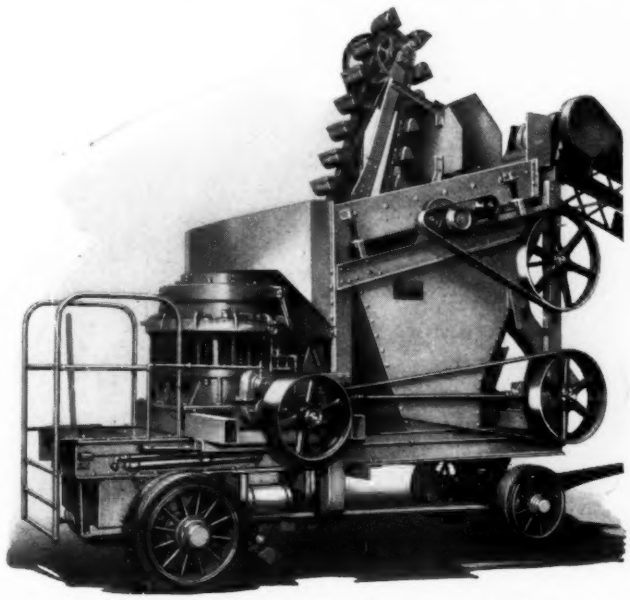
The locking arrangement on the portable box was the result of close cooperation between the Cincinnati Department of Highways and the manufacturer. There are no padlocks; just a positive locking mechanism that by means of one lock fastens the double covers simultaneously full length of the box. On large jobs, where tool boxes are left on the street, it is not necessary to keep a watchman through the night as unauthorized persons cannot break into the box.

A New Portable by Telsmith

A new portable crushing-screening-loading plant, designed to meet the latest trend in highway specifications which in most states now call for finer rock, has been developed by the Smith Engineering Works, Milwaukee, Wis. This smith No. 24 cone crusher is recommended by the manufacturer. This is a steel gyratory-type crusher with an umbrella shaped head and unobstructed feed opening, operating at high speed with a graduated crushing stroke and spring release against choking.

For coarser crushing 3/4 in. to 1 in. rock, in moderate capacities the makers equip the outfit with a Telsmith-Wheeling jaw crusher. It is a roller bearing jaw crusher, equipped with massive frame and swinging jaw, both annealed cast steel, and has manganese steel jaw dies and cylindrical roller bearings.

All standard Telsmith portables are equipped with: A Telsmith standard plate feeder, 16 in. x 5 ft., self contained, with a steel supporting frame; and having an eccentric which is adjustable to



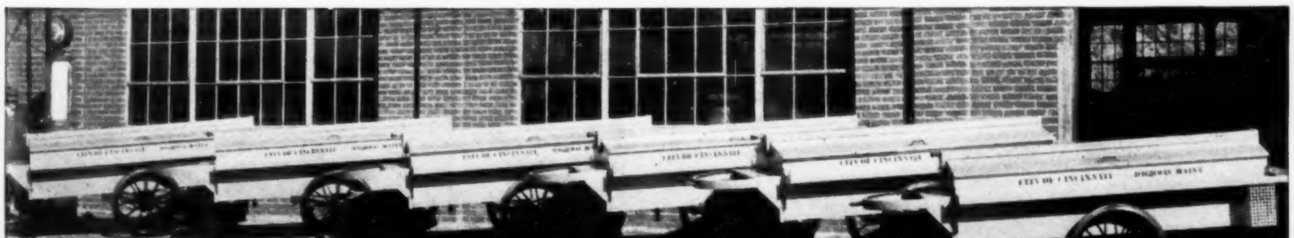
New Telsmith Portable Crushing-Screening-Loading Plant

new portable outfit is equipped with a standard, large commercial plant type crusher for finer reduction in large capacities.

It is further distinguished for its large screening capacity, being equipped with a vibrating screen. Another feature of the new Telsmith is that it may be furnished interchangeably with a No. 24 cone crusher; or a Telsmith-Wheeling jaw crusher in any one of four sizes.

For fine crushing in large tonnages, products finer than 3/4 in. and larger capacities for 3/4 in. to 1 in. rock the Tel-

function at different capacities. Telsmith standard vibrating screen, 3 ft. x 8 ft., an all-steel, roller-bearing vibrator designed to give uniform balanced vibration under all conditions of load, with maximum output, two Telsmith conveyors, a 42 ft. feed conveyor; also 50 ft. finished product conveyor and 10 or 20 yd. portable steel bin, or when preferred, a short conveyor for loading direct to trucks. Metal wheels are standard equipment, but where frequent moves are necessary rubber tired wheels are available at slight extra cost.

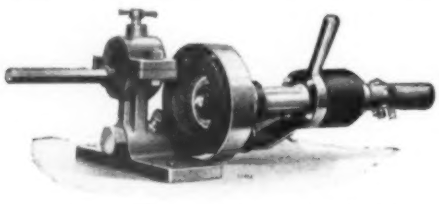


Six HanDee All-Steel Portable Tool Boxes, Purchased Recently by the Highway Department of Cincinnati, O.

I-R Shank Grinder

Ingersoll-Rand Co., 11 Broadway, New York, announces the 4K shank grinder, a tool for facing the striking ends of drill steel shanks, rock drill and paving breaker pistons, and anvil blocks.

The machine consists of a "Multi-Vane" air grinder mounted in a frame so as to allow the grinding wheel to be passed back and forth by means of a handle. The grinder mounting is fitted with a wing nut adjustment working under spring tension for feeding the wheel up against the face being ground.



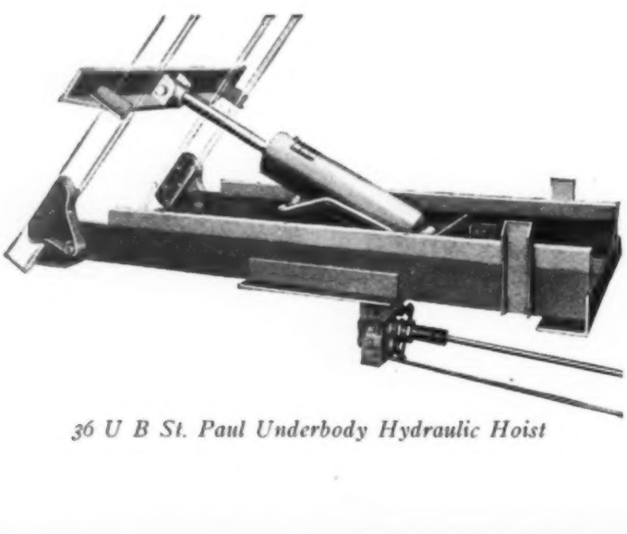
Ingersoll-Rand 4-K Shank Grinder

The steel or piston is held in a self-centering "V" block clamp incorporated in the frame. A countersinking bit is located in the center of the grinding wheel for removing the burr from the hole in hollow drill steel. The complete machine can be bolted securely to the top of a work bench or other suitable location.

The 4K grinder is stated to insure the uniform and correct dressing of striking faces and eliminates rounded drill steel shank ends and cupped pistons, which are responsible for much of the spalling and breaking of these parts.

New Underbody Hydraulic Hoist

A new underbody hydraulic hoist for 1½ ton trucks has been brought out by St. Paul Hydraulic Hoist Co., St. Paul, Minn. Some of the outstanding features of this new 6 in. St. Paul hoist are as follows: Cylinder—6-in. with support for base rigid to sub-frame; piston rod—Oversize—2-in. diameter. Large and husky with sturdy body attachment; pump—Large size with ball check valve. Stationary and does not move with hoist; drive—Straight line eliminating special or additional universal joints and also no special support bracket needed; controls—Inside of cab, no leg interference; mounting height—Low and convenient but sufficient for tire clearance; hinges—Oversize and sturdy with 1½-in. hinge rod; body guides—Strong and husky—channel iron type; wood sills—Attached to hoist sub-frame as a cushion for body and to eliminate noise; sub-frame—Steel—Full length. Distributes load equally over chassis frame; oil pipes—Action of oil through the high and low pressure pipes is such that the seal increases with the pressure; installation—Extremely simple. Not necessary to cut off the end of the chassis frame as with other jobs. The tire carrier is also undisturbed.



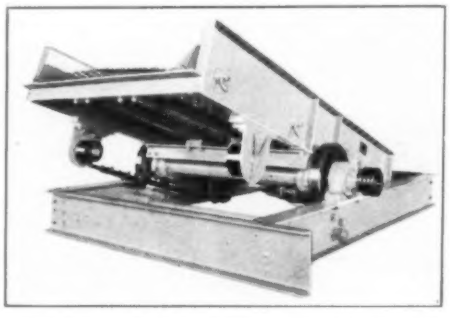
36 U B St. Paul Underbody Hydraulic Hoist

New Heavy-Duty Vibrating Screens Announced by Link-Belt

Two new types of vibrating screens have just been announced by Link-Belt Co., Philadelphia, Penn. These screens are known as:

(1) Link-Belt positive-drive type, heavy-duty vibrating screen, which is made with both single and multiple decks.

(2) Link-Belt unbalanced-pulley type, heavy-duty vibrating screen, made with single and multiple decks.



New Link-Belt Heavy-Duty Vibrating Screen

In the positive-drive type screen, the amplitude of vibration is fixed at the factory, before shipment, to suit the work the screen is to do. Any given amplitude will cover a wide range of screening surface openings. The angle of the screen inclination, the speed of operation and the direction of the rotation, all are readily changed at any time to suit the kind, size and condition of material to be screened. The rotation determines whether the vibrations are with or against the flow of the material.

Cantilever leaf springs serve to maintain the screen box at a constant angle, being adapted for the circular motion produced by the action of the eccentric-driven positive drive. Oversize self-aligning spherical roller bearings are used. A steel sub-frame is regularly furnished as a part of the screen, and it can be supported from below, or hung by cables from above.

The unbalanced-pulley type, heavy-duty screen is available with single or multiple decks, for high speed work where the material is of a sticky nature, and on close-sizing problems where the screen openings are not large.

The total movement, or amplitude, of the screen can be varied by the user, from zero to about ¼ in., by simply changing the counterweights in the weight containers,—a valuable feature where screen cloth openings must be changed frequently, and when the condition of the material handled is likely to vary as to moisture content, etc. The angle of the screen and the speed and direction of operation can also be changed readily by the user, to suit operating conditions.

The entire weight of the screen box rests on the cantilever leaf springs, and responds to the reactions therefrom. The bearings, the method of applying screen cloth, and the cantilever leaf spring design, are the same as on the positive-drive type of screen, above referred to.

Oil Retention Construction for Ball Bearings

An improvement in oil retention construction for ball bearings was recently granted George O. Hodge, Plainville, Conn., and assigned to Standard Steel and Bearings, Incorporated also of Plainville. The patent number is 1,839,677.

The oil retainer, or seal is composed of two circular plates wedged together into a groove in the the outer ring of the bearing. Contained between these two circular plates is a wiper or ring of felt that makes contact with the inner ring of the bearing, Figs. 1 and 2, or with a shaft, Fig. 3. The felt wiper or ring forms an oil-stop or dam that retains the lubricant within the bearing.

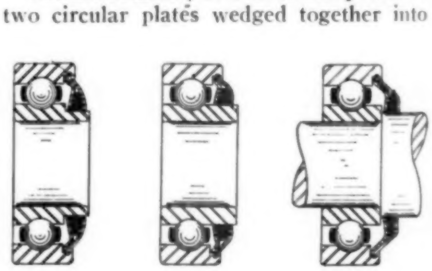


FIG. 1 FIG. 2 FIG. 3

Figs. 1, 2 and 3

Plate construction and assembly are such that there is a constant pressure against the felt ring between the plate members, this pressure tends to constantly press the felt ring against the rotating inner ring or shaft so as to improve the sealing contact and to take up wiper wear as it develops.